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NOVEMBER 1957

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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November Night

Listen . . .
With faint dry sound,
Like steps of passing ghosts,
The leaves, frost-crisp'd, break from the trees
And fall.

—ADELAIDE CRAPSEY

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HIGHLIGHTS OF THE 1957 CONVENTION PROGRAM

3. SECTION MEETINGS AND LUNCHEON PROGRAM

LOUIS PANUSH
Vice President, CASMT, 3437 Oakman Blvd., Detroit, Michigan

This is the last in the series of brief articles describing the most important features of the program of the 57th annual convention of *Central Association of Science and Mathematics Teachers* which will be held at the Congress Hotel in Chicago, November 28–30. We hope that this preview will not only encourage members and friends of the Association and readers of this *Journal* to attend this outstanding professional gathering but will enable them to plan their convention stay to the best possible advantage.

Previous articles dealt with the various activities on Friday:

1. The morning general session with *Dr. Stuart McLain*, Associate Director of the Argonne National Laboratory, as main speaker. This will be followed by a demonstration of *experiments* and *demonstrations* in the area of atomic energy that teachers will be able to utilize in their classrooms. This demonstration period, running from 10:15–11:45 A.M. will feature a closed circuit TV telecast sponsored by Dage TV Division of Thompson Products, Michigan City, Indiana.
2. A major, all-afternoon tour to the *Argonne National Laboratory*.
3. Another major tour to the *Adler Planetarium* where a special show and lecture will be presented by the Director, Mr. Albert V. Shatzel. This will be followed by two sub-tours: one to the ***Museum of Science and Industry*** to view and learn about the "World of Numbers," "Atoms for Peace," and "Geometry"; the other to the ***Museum of Natural History*** to observe a "behind-the-scenes" presentation of the fundamental principles underlying the preparation of displays and exhibits.

4. An afternoon program for those who will not join the tours (since they are limited) on ***What's Newest in Science***, featuring: a) James R. Irving, Scientific Apparatus Makers Association, on "What's Newest in Scientific Apparatus"; b) "What's Newest in Science Classroom Equipment" by a representative of a major equipment company; and c) "What's New in Teaching—Method and Technique" by Walter Gohman of Iowa State Teachers College; and on ***What's Newest in Mathematics***, presenting: a) "The Role of Meaning in Teaching the Fundamental Processes," by Dr. Herbert Hannon of Western Michigan University; b) "Mathematics in General Education," by John C. Bryan of North High School, Omaha, Nebraska; and c) "Plans for the Reorganization of College Preparatory High School Mathematics," by Albert E. Meder, Executive Director of the Commission on Mathematics, New York City.

5. A continuous showing of the newest films in all areas of science and mathematics, on all levels.

6. The evening general session with ***Dr. Harold C. Urey***, Nobel Prize Winner in Chemistry, speaking on "Science, Mathematics, and Culture."

7. General reception for convention attendees with provision to meet speakers, outstanding guests, and socializing. Feature: honoring Dr. and Mrs. Glen Warner for their many years of faithful and invaluable service to the Association.

This article will deal briefly with the activities on Saturday. This year the traditional convention program has been radically changed in that the section meetings and the luncheon will be held on Saturday instead of the usual time on Friday. More time was allotted to the section meetings and the programs offered are dynamic and very worthwhile, especially designed to meet the needs and the wishes of the membership. Several sections will have combined meetings for greater effectiveness both in program and attendance.

A brief resume of the individual section programs follows.

The ***Biology*** and ***Conservation*** sections will present a combined program featuring illustrated talks by Dr. Marjorie Causey, Indiana State Teachers College, on "The School Camp—A Part of the Total Conservation Program," and Dr. Elzada U. Clover, University of Michigan, on "Special Techniques for Teaching Plant Growth in the Classroom." Both are authorities in their field and excellent speakers.

The ***Elementary Mathematics*** and the ***Elementary Science*** sections have combined their efforts to present a meaningful program based on "Unifying Ideas in the Arithmetic Curriculum" by Dr. Richard D. Crumley, of Iowa State Teachers College, and on "Creativity in the Teaching of Elementary Science" by Illa Podendorf, of the University of Chicago Laboratory School.

The *Chemistry* section will have a most unusual program combining classroom procedures and demonstrations with the industrial point of view. Mr. J. R. Howell, Union Carbide Chemicals Company, will speak on the "Student 1957—Chemist 1965;" "Demonstrations You May Use" will be presented by Dr. T. A. Nelson and Mr. Elmer Chessman of Lyons Township High School and Junior College, La Grange, Illinois; and a most interesting symposium by students from the Seminar for Talented Youth at Evanston Township High School, Illinois, on "Science, As We Like It" will be moderated by Mr. William E. Jones, Chairman of the Science Department.

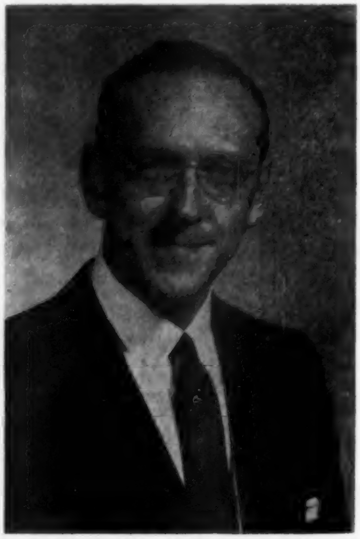
Dr. Edwin J. Schillinger, of De Paul University, Chicago, and Mr. B. F. Auer, of Goodyear Atomic Corporation, will share the platform in a lecture-demonstration program on "Educating the High School Student for Atomic Defense" for the *General Science* section.

The *Mathematics* section will feature a "Program for the Gifted in High School Mathematics." Mr. W. J. Cherry, of J. Sterling Morton High School and Junior College, Cicero, Illinois, will discuss the program as it affects the 9th and 10th grades, while Mr. Joseph Kennedy, of Wisconsin High School, will emphasize the mathematics program for the 11th and 12th grades at his high school.

The *Physics* section will certainly appeal to all physics and allied teachers with its presentation. Dr. Edson Peck, Northwestern University, will give an illustrated talk on "The Physics of Earth Satellites"; Dr. Clarence J. Overbeck, Northwestern University and President-Elect of A.A.P.T., will tell "How the High School Teacher Can Inspire Young People to Prepare Themselves Adequately for College"; and Mr. Almond C. Fairfield will moderate a panel of representative teachers on the subject of a "Physics Laboratory for Critical Thinking."

For the first time in many years, the annual *luncheon* will be held on Saturday noon. It promises to be an outstanding event, fitting to close an eventful convention. The speaker will be *Dr. G. Truman Hunter*, Consultant in the Executive Development Department of the International Business Machines Corporation. His topic is "Minds, Mathematics and Machines." It will fit with the general theme of the convention with emphasis on the modern electronic giants as they are used in industry, in scientific research, in promoting the welfare of the people and their impact on society, and what teachers can do in the classroom to promote the understanding of the problems involved. Dr. Truman has an impressive academic and industrial background; a graduate degree in experimental nuclear physics with a minor in electronics engineering, university experience in research and in teaching physics and communications and extensive business experience since joining IBM in 1950. And he comes to us

with the highest recommendations as to his ability as a very interesting and informative speaker.



Dr. G. Truman Hunter
Luncheon Speaker, Saturday Noon

The Officers, the Board of Directors and the Section Chairmen take great pride in presenting what they believe will be an outstanding convention. The Local Arrangements Committee and the various members responsible for the physical set-up and the social aspects have contributed time and energy to make this convention the most hospitable and sociable affair. For knowledge, for professional growth, for *new horizons in the teaching of science and mathematics*, for a great opportunity to visit with and meet old friends and make new ones—it's the 1957 convention of CASMT in Chicago, Congress Hotel, November 28–29. The Yearbook will give you the detailed program. If you have not received it, write for it.

DISCOVER NEW KIND OF PLUTONIUM, ELEMENT 94

A new kind of plutonium, the atomic fission bomb element, has been discovered by a team of University of California scientists.

The new isotope is plutonium 233. It is the 13th known chemical twin of plutonium. Isotopes are varieties of the same element, having the same chemical properties but different structure inside the nucleus.

Plutonium 239 is the most important isotope, being fissionable by slow neutrons and capable of sustaining a fission chain reaction. The A-bomb dropped on Nagasaki in World War II was a plutonium bomb.

SCIENCE BOOKS FOR THE HIGH SCHOOL LIBRARY

S. C. Chandler
Science Librarian, Brigham Young University, Provo, Utah

Nearly all science teachers agree that the modern high school library should provide science books that supplement the regular texts. Apathy reigns among them, nevertheless, when it comes to choosing the books. Leave it to the librarian or the book committee, seems to be the rule. Unfortunately, however, most librarians are not familiar enough with science to choose such books confidently, and most book committees are dominated by teachers who are poorly trained bibliographically, and also lack scientific backgrounds.

In the school where these things are true of the librarians and the book committees, the science teachers can render invaluable service if they will recommend books for first and second purchase.

To be of value, such recommendations should be made after the teacher has weighed the books according to some basic principles of book selection. Among them are the following:

1. Every book recommended should possess the qualities of good composition. This means the style should be balanced so that it will fit the content of the book, yet not be too scholarly nor too elementary for high school students to follow and enjoy. It should show the author's originality, power, enthusiasm, profundity, and vitality. Moreover, the vocabulary should challenge the students, but not be too technical for them to understand. Of course, the grammar should be correct, and the punctuation correspond to that demanded by English teachers. Although some authors argue that scientists should use some form of simplified grammar, such a practice is not recommended for books that high school students must use.

2. The material in every science book regardless of the nature of the book should be organized around a central theme which is worthy of presentation and is not too obsolete, too often discussed, too general, nor too limited.

3. The material should be arranged into topics and chapters that follow each other in a sequence that allows the reader to progress from point to point without difficulty and without being thrown off balance by congestion in some parts of the book and weakness in others.

4. The subject matter should be illustrated amply with pictures, maps, graphs, and charts, and with examples and other types of explanations.

5. Because most science books are used as reference sources, all such books, except fiction, should have an index, a table of contents, footnotes, bibliographies, and a preface that explains the author's aim.

6. The subject matter should be based upon accepted facts and serious research. The observations and conclusions should show that the author has exercised sound judgement.

7. The author of every book that is recommended should be recognized for his qualifications to write upon his subject. The works of professional popularizers and of scientists who pose as authorities in many fields should be closely examined. On the other hand a work that is a collaboration of scientists and literary men or journalists should be considered. Many times this type of book appeals to high school students more than those produced solely by scientists.

To some teachers it may seem that compliance with these eight principles will demand too much of their time. But this is not true. As many teachers and librarians testify there are tools that expedite book selection and at the same time make it an interesting and informative activity.

Among the most useful of these tools are the book reviews that appear in SCHOOL SCIENCE AND MATHEMATICS and other excellent professional journals and also in the general science magazines that come to nearly every school. Other excellent book reviews can be found in the book selection tools that librarians receive—for example, *Standard Catalog for High School Libraries* (New York: H. W. Wilson Co., 1952), and the *Basic Book Collection for High Schools* (compiled by a Joint Committee of the American Library Association, National Education Association and the National Council of Teachers of English.)

PREDICT SOLAR ENERGY WILL COOL HOUSES

Solar energy will be used both to cool and heat houses by the year 2000.

Mr. John I. Yellott, executive director of the Association for Applied Solar Energy, Phoenix, Ariz., predicted that by the turn of the century fossil fuels will be in short supply and their prices will be far above today's relatively low figures. Atomic energy will carry a major share of the increased electric generating load while solar energy will provide year-round comfortable temperatures in houses and office buildings.

Solar radiation is the world's only "inexhaustible" energy source. It is abundantly available in the United States and in most of the earth's densely populated sections.

For most uses of solar energy, large areas of some variety of radiation-absorbing surface are needed. It is predicted the first will be made of metals rather than plastics. Transparent covers are also needed to trap the heat and these require large amounts of glass or plastic, such as the new weatherproof plastic films.

Mr. Yellott envisions "roofs made of prefabricated panels of Mylar, tubed sheets of aluminum or copper, and Dacron" (for insulation) to replace conventional materials, collecting sufficient solar energy for both winter heating and summer cooling.

Certain solar radiations cause many chemical reactions, the most important of which is photosynthesis. The future will bring a far better understanding of the process by which light is used by growing plants, and that knowledge will enable us to produce more and better food.

SYMPOSIUM: RECENT RESEARCH IN SCIENCE EDUCATION

A symposium presented before a Session of the National Association for Research in Science Teaching at the Eighth Joint Conference of the Science Teaching Societies Affiliated with the American Association for the Advancement of Science in the East Room, Hotel Sheraton-McAlpin, New York City, at 9:00 A.M. on Thursday, December 27, 1956.

The symposium here described is the third presented at the convention of the AAAS. The first was presented at the Berkeley Convention in December 1954; the second at the Atlanta Convention in 1955; and the third in New York in 1956. The attendance at these symposia has attested to their popularity.

In general, the function of these symposia has been to present in a non-technical fashion, summaries of research in science education at the elementary, secondary and college levels. These are followed respectively by brief reports of the implications of this research.

The papers that follow are the reports that constituted the New York Symposium. They appear in the same order as on the program.

SURVEY OF RESEARCH IN ELEMENTARY SCHOOL SCIENCE EDUCATION

George Greisen Mallinson
Western Michigan University, Kalamazoo, Michigan

Introduction

The purpose of this report is to summarize in a non-technical fashion the findings of research in the teaching of elementary science undertaken since that reported in the Third Annual Review of Research in Science Teaching of the NARST.[1] The research studies were located by searching through the appropriate literature published during the period July 1, 1954 through November 1, 1956. Unpublished studies such as theses, dissertations and curriculum reports were not included because of time limitations. The studies thus located were read carefully, their findings analyzed, and were then categorized under headings to which they seemed logically to belong.

The report that follows summarizes the findings of the studies grouped under the various categories. Since the presentation is non-technical, none of the contributing studies are cited. Further, no implications are made since they will be given by the next speaker.

[1] Mallinson, Jacqueline Buck (Chairman), "Review of Recent Research in the Teaching of Science at the Elementary School Level I." *Science Education*, XXXIX (December 1955), 336–43.

What Is the Relationship of the Training of Teachers to the Elementary Science Program?

Three published research studies were found that dealt with this question. Surprisingly, all dealt with almost entirely different aspects of the problem. One considered the contributions of the normal schools to the historical development of the elementary-school science program, another with the present program for training elementary teachers to teach science, and the third with suggestions of elementary teachers for in-service workshops in science teaching.

Contrary to popular belief, the actual science content of the curricula in the early normal schools was extensive, often consisting of twenty to forty per cent of the total number of hours elected by the student. Apparently the normal schools had accepted the idea that science training was necessary for elementary teachers. However, the value of the science program was considerably less than its volume. Courses in biology in this program generally emphasized the "nature study" approach, namely emphasis on structural characteristics and identification of representative phyla. Those in the physical sciences dealt with the laboratory and analytical approach to science with emphasis on experimental controls. The objectives of these courses were not consistent with the generally accepted objectives of elementary education. As a result much of the emphasis on science in the normal schools was wasted.

The more recent studies tend to suggest that science programs for elementary teachers in present-day universities and colleges are fairly similar in content to those found in the early normal schools. However, the prospective elementary teachers elect fewer science courses. In general, the science courses they do elect are designed as introductory experiences for students intending to major or minor in the respective subject-matter fields. The prospective elementary teachers ordinarily elect two of these courses although they seldom include both the biological and physical sciences. Apparently, the "academic approach" of these courses deludes the prospective elementary teachers into believing they are equipped with the subject matter necessary to teach elementary science. Yet, scores they obtain on tests covering the subject-matter taught in the generalized sciences fail to support their beliefs of such competence.

Despite their apparent belief that these courses supply them with the needed competence, most of the prospective elementary teachers indicated that they would have preferred to have elected generalized courses of the survey nature had they been available.

Experienced elementary teachers when asked about desirable activities for in-service workshops in science tend to suggest those that are not found as part of the science courses they have taken in col-

lege. Few of their suggestions deal with the need for additional subject-matter. Rather they point to the need for help in making use of community resources for teaching science, and in the development of laboratory experiences suited to children. Especially significant was the view that such workshops should be at least partly planned or structured ahead of time.

What Emphases Have Been Found in Recent Research Studies in the Curriculum for Elementary Science?

An examination of recent research indicates that the rash of "status studies" concerning the elementary-science curriculum has died out. Most of these "status studies" described the unfortunate situation in elementary science but offered few suggestions for correcting it. The research dealing with curriculum that was located for this report was sparse. However, it did seek to identify the characteristics of adequate programs for elementary science.

These studies seem to indicate that "ideal" programs of elementary science devolve on a continuous development of science experiences throughout the grades, and on science activities that have been planned definitely ahead of time but with the opportunities for flexibility. In general such experiences and learnings in science are often most effective when they are integrated with learnings in other areas and especially when they afford opportunities for social interaction among the students. In general, these views for flexibility seem to support the findings of studies in which efforts have been made to allocate the teaching of certain science principles to specific grade levels. Apparently it is impossible to get substantial agreement for such allocation from elementary teachers and supervisors.

All these studies emphasize further that the procedures for evaluation must be part of the curriculum itself. Unfortunately few of them offer any specific suggestions for the optimal way for the continuous evaluation of the science program.

In short, these more recent studies place less emphasis than do earlier studies on the acquisition of functional facts, and the functional understanding of scientific principles as outcomes of science teaching in the elementary school. Rather they seem to suggest that elementary science experiences should be designed to contribute to the broader work-study skills considered to be the outcomes of the total instructional program of the elementary school.

What Factors Are Related to Achievement in Elementary Science?

The number of studies relating to this question either substantiate data already available or offer fragmentary evidence to questions that are already matters of conjecture.

One conclusion seems to stand out above all others, namely, that the factor of intelligence bears a greater relationship to achievement in elementary science than any other. Superior students seem to profit by any methodology or type of experience. Yet even though the superior student achieves far more than the poorer one with any methodology, his increment of achievement under what is considered to be an adequate program is not significantly greater than that under an inadequate one. The poorer student, however, profits significantly more under the adequate program.

One study that appeared contains data that suggests that boys seem to achieve more than girls in so far as the results on tests in elementary science are concerned. However, the evidence is not sufficiently substantial to warrant disregarding a number of other studies in which the conclusions seem to point to the contrary.

Another group of studies seem to point out that rural students achieved somewhat, although not significantly more, than urban students in elementary science. This finding seems to be consistent with the findings of another study which indicates that a profusion of outdoor experiences in science increase achievement, at least on tests of science. The greater opportunity for such experiences for rural than for urban children is obvious.

What Do Results of the Evaluation Programs of Elementary Science Show?

A number of studies deal directly with this question. Others deal only tacitly. Yet putting them together, the generalizations that may be drawn are worthy of note.

In general, adequate programs of elementary science do not seem to be expensive. The majority of schools with good programs do not spend excessive amounts of money for material and equipment or for the employment of specialized personnel. Generally, it seems that inadequate programs of science are found in elementary schools where teachers lack facility in using the best science teaching procedures, rather than in schools where equipment and specialized help are not available. A number of schools in which the science program is inadequate in terms of accepted standards apparently have been unaware of these inadequacies. In many of these schools the staff has been lulled into complacency by the fact that the students have achieved good results on short form achievement tests.

These studies together suggest, as have many of the studies already discussed, that a successful program of elementary science depends greatly on the ability of the teacher and the extent to which the results of a program of continuous evaluation are heeded.

To What Extent Are Textbooks of Value as Instructional Materials in Elementary Science?

The findings of the recent research studies concerning printed materials for elementary science support substantially those of earlier studies. In brief, there is no significant advantage of any one methodology over any other, provided it is used judiciously by a skillful teacher. The reading of textbooks and other printed material seems to be as effective for learning in certain science areas as does the laboratory approach in the same area. The studies however are not sufficiently broad to suggest that these conclusions may apply to all areas of science learnings.

The studies do point out however that regular textbooks for elementary science, as well as the unit-type textbooks, can be improved. As now written they are frequently too difficult for the students for whom they are designed, and frequently are out of date. Further, many contain topics and areas that are well below the level of sophistication of the elementary children who use them. The element of flexibility of use is also one feature which seems to have evaded the authors. These studies point out, therefore, that judicious use of these materials is most important.

To What Extent Are Laboratory Manuals Useful in Elementary Science?

Only one study was undertaken in this area and that for the field of general science. However, since the findings are applicable to elementary science, it was decided to mention it here briefly.

Most of the laboratory manuals for general science contain the exercises in the areas that most teachers find suitable. Yet few of these exercises actually emphasize scientific methodology and the work-study skills considered to be desirable outcomes for elementary or general science. Most of them seem to contain experiences that deal chiefly with manipulative skills. It would seem that the philosophy of the science courses in the normal schools is still reflected here.

Summary

A summary of a review would be redundant. Yet it is almost impossible to evade the broad generalization that a competent teacher whose science teaching exemplifies the generally accepted objectives of elementary education adds up to an adequate program of elementary science.

IMPLICATIONS OF RESEARCH IN ELEMENTARY SCHOOL SCIENCE EDUCATION

HARRY MILGROM
Supervisor of Science, New York City Elementary Schools

INTRODUCTION

According to the survey made by Dean George Mallinson, research studies in elementary science education of the past few years have sought to determine to what extent the success of a program of science instruction in the elementary schools is dependent on:

1. The training of teachers.
2. The design of the curriculum.
3. The nature of the pupils.
4. The methods of evaluation.
5. The use of textbooks.

Since the actual findings of these investigations have already been summarized, it is the intent of this report to examine the implications of the findings and suggest some answers to the question, "Where do we go from here in elementary science education?"

What Kind of Training Should Prospective Teachers Get to Prepare Them to Teach Science in the Elementary Schools?

A teacher should be fond of children and be genuinely interested in their growth and development. A teacher should be a sympathetic guide and companion to her children. She should have a deep appreciation of their individual needs and abilities and be familiar with the basic drives which shape their learning patterns.

On the day a baby is born, he begins his search for understanding of the world around him. At first his explorations are confined to a world of very small dimensions. As he grows older and his powers of perception develop, his search moves outward in spreading ripples. By poking and probing, by looking and listening, by feeling and tasting, he tries to bring some order to the chaos of impressions which beat down upon him. When the child is able to talk, he starts his incessant questioning.

At just about the right time for the exhausted parents, the elementary school opens its doors to receive the youngster. He enters the building with mixed feelings of awe, wonderment, and great expectation. In what ways will the school enable him to obtain the knowledge and understanding which he seeks? Because of the spectacular scientific developments of the past fifty years, today's child is surrounded not only by the wonders of nature, but also by the many wonders wrought by the ingenious mind of man. For him, light floods the room not only at sunrise, but also when an electric bulb is turned on at

the switch. For him, water comes not only from rain clouds, but also from an opened faucet. For him, not only birds wing across the sky, but also jet planes moving faster than the sound of their own engines. For him, a friend's voice can come not only from across the street, but also over the telephone lines from a far distant city. For him, the wonders of the world parade not only outside the window, but also across the glowing window of a television set.

Teachers in the elementary schools should be able to provide exciting programs of exploration that will challenge and stimulate today's science-minded youngsters. It seems clear that neither the early normal school type of training course which emphasized routine identification, classification and laboratory manipulation, nor the present day college training course which is designed for students intending to specialize in science can give the prospective grade school teachers the content, methods, materials, and techniques they need for conducting *elementary science* programs. A functional course should give the teachers-in-training the kind of science that they will be expected to give the children. By setting an enthusiastic example and by providing real firsthand experiences, the instructor can help the future teachers learn

—how to keep alive curiosities.
—how to stir new wonderment.
—how to arouse interests.
—how to whet science appetites.
—how to get young minds to think and reason.
—how to initiate investigations.
—how to devise intriguing experiments.
—how to develop problem-solving skills.
—how to make effective use of community resources.
—how to relate science to familiar elements in pupils' lives.
—how to preserve and nurture the inner drives that impel children to search for understanding.

Furthermore, the instructor should conduct his own course in a way that will show that science learning involves more than the mere transfer of a miscellany of scientific facts from teacher to pupils, and back again from pupils to teacher. A training course should equip teachers with a great deal of inspirational "Know-how" and the appropriate amount of encyclopedic "Know-what."

To upgrade experienced teachers along the lines indicated, many boards of education are setting up special in-service programs. A long-range plan for training elementary school teachers in New York City includes:

—a three year project to establish an elementary science curriculum. Supervisors and teachers serving on committees and in pilot schools of the project receive basic training through this work.
—publication of a comprehensive teacher handbook in elementary science.
—exploration of community resources.

—expanding of science consultant services.
—utilization of television, radio, films and filmstrips.
—special courses given by museums, zoos, botanic gardens and the planetarium.
—do-it-yourself workshops to allay teacher fear of handling science materials.
—city-wide conferences on school time.
—district seminars and institutes involving about twenty-five schools in each of twenty-five districts.
—faculty and grade meetings.

The time is now for children to begin to acquire the knowledge, insights, appreciations and abilities, that will enable them, as tomorrow's citizens, to comprehend the on-rushing developments in science, and to cope with the problems left in their wake. The time is now for training programs to give present and future elementary school teachers the vision and competencies needed for this crucial educational task.

What Are the Characteristics of an Adequate Curriculum in Elementary Science?

Science in the elementary schools can contribute many unique values to the total instructional program. It is not expected that the study of science at this level will make scientists of all the children. Nor is it expected that the science program will encompass all the science known to man. Rather it is expected that through work in science, children will:

—engage in leisurely exploration of the wondrous world around them.
—learn the answers to questions that puzzle them.
—experience the thrills that come with discovery.
—begin to organize discreet findings into generalizations.
—become familiar with experimental procedures.
—learn the many ways of finding out.
—grow in their ability to observe carefully, report their observations, make predictions based upon these observations, and check their findings.
—grow in their ability to make measurements.
—develop initiative and resourcefulness in tackling problems.
—become more secure as they learn the causes of natural phenomena.
—become more responsible as they learn the meaning of cause and effect.
—learn to cope with new and unexpected situations.
—learn to work together.

Judgment of a science program should not be based on how many science topics a teacher covers, but on how well she uses selected topics to achieve the more important values indicated above.

An adequate curriculum offers a graded sequence of classroom tested science topics and activities. It gives teachers the security of a planned approach, yet leaves plenty of time for teachers and children to "go awandering."

An adequate curriculum indicates where and how specific understandings and skills can be developed. It provides special procedures

for challenging the brighter students and maintaining the interest of the poorer ones.

An adequate curriculum includes science experiments specifically geared to the abilities of young children and based on simple materials readily available to them. It emphasizes the importance of giving children as many firsthand experiences in science as possible.

For many years, science has been a tiny appendage on the large structure called the total elementary program. Today, with science playing an increasingly important role in shaping our culture and controlling our destiny, this proportion no longer meets the needs of society. It is entirely conceivable, in this age of the atom, that work in other areas such as the three R's might stem from a good program of science instruction.

What Factors Should Be Considered in Evaluating the Science Attainments of Different Children?

Because children have different backgrounds, interests, and abilities, they all cannot be expected to derive the same benefits from their work in elementary science. Some will amass a fund of general information. Others will develop skill in devising and constructing experimental materials. Some, intrigued by the intellectual challenge of science, will become proficient at making bold hypotheses. Others will learn to care for living things, without necessarily knowing to which phyla they belong. Some, in acquiring deep insights, will miss the trees for the forest. Others, sticklers for facts, will miss the forest for the trees. One child will be inspired to become an avid reader. Another will be inspired to become an energetic doer. One child will look to the stars. Another will look to the atoms.

It seems clear that achievement tests which, in the main, test only for factual recall, cannot reveal the science gains made by large numbers of pupils. If achievement tests are to be used as diagnostic instruments, the tests themselves must be carefully evaluated. Thus, one such science test is heavily weighted with nature questions. Is it not to be expected that rural children will show greater achievement than city children on such a test? However, the importance of nature experiences for urban children is recognized in New York City and the science program promotes indoor and outdoor gardening, trips to and work in wildlife sanctuaries, museums, zoos, and botanic gardens, plant growing and flower arranging shows, and pet care activities. Teachers are encouraged to participate in Audubon nature camp workshops, on scholarships furnished by the City Gardens Club.

Some research indicates that boys tend to achieve more than girls in their science work. This may be due to seepage into the test, the science program, or both, of outmoded social taboos against women

entering the fields of science and engineering. Now is the time to examine critically all science teaching from elementary school to college to remove those influences that tend to dissuade girls from preparing for careers in science.

Other research indicates that "poorer" students show a greater increment of gain than "superior" ones when better methodology is used. That, of course, is good. But, here too, the validity of the testing instrument must be questioned. Since "superior" students are able to acquire facts when any, or even no methodology is used, it is not surprising that tests based on factual recall show no significant gains for such students when the better methodology is used. What the tests apparently fail to measure is growth in understanding of concepts and problem-solving power.

At the elementary level, curricula can and should be designed to give all children, regardless of sex or intelligence rating, opportunities to experience the joys of discovery and accomplishment in some phase of the science program.

Summary

With art kits now available, anyone can paint a "masterpiece" in oils. The painting is created by applying to numbered spaces on a canvas the colors squeezed from correspondingly numbered tubes of oil paint. If art teachers were to use this procedure to develop in children the skills and insights needed for creative art, they would be roundly condemned.

Science teaching which uses this type of approach is just as insufferable. Science teaching which begins and ends with the perfunctory filing of numbered science facts in correspondingly numbered compartments, cannot reveal to children the true nature of man's great intellectual adventure called science.

SURVEY OF RESEARCH IN SECONDARY SCHOOL SCIENCE EDUCATION

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Introduction

This survey of research in secondary school science education deals with twenty reports published during the period of August 1954 to about February 1956. The studies have been arranged under five major categories, and the number of researches in each is given.

A. Trends in Organization, Administration, and Current Practices 2,

B. Curriculum Construction and Materials 6,
C. Evaluation Studies 5,
D. Programs for the Gifted Student 4,
E. The Shortage of Science Teachers and Science Workers 3.

Some studies though classified in a given category may have elements in common with other categories. For example, an evaluative study of reading difficulty may overlap to some extent with curriculum materials. It should be kept in mind, therefore, that the categorical grouping of studies is somewhat flexible.

Some research studies in secondary science education have not been published as yet in professional journals. Abstracts of these studies are published by the United States Office of Education in a special circular and in the special issue of *Science Education* devoted to the annual review of research. Many of the studies will eventually be published in professional journals.

Let us now turn to an examination of the developments in research in secondary school science education using the categories described above.

A. *Trends in Organization, Administration, and Current Practices*

Many state departments of education publish bulletins describing the number of courses given in various sciences, the number of teachers certificated to teach science, the average class sizes, and other data. The status quo is described but the effectiveness of the plan of organization is not evaluated. The Bulletin of the California State Department of Education (4), "Science Instruction in California High Schools," July 1955, is only one example of many. In all fairness it should be stated that evaluation would require a large expenditure of time, personnel, and cost and that the factual surveys made are commendable as steps in the right direction. More critical evaluation is needed and should be encouraged.

Mallinson (14) reported on the trends in science education in Michigan in which he discussed the combinations of science taught by science teachers, the subject matter backgrounds of science teachers, and the types of training desired of science teachers by their supervisors. Data were collected by means of a questionnaire to the school administrators and teachers. A majority of the instructors were reported as teaching two or more sciences. Many teachers who were teaching only one science were not prepared in the field of science but were filling in.

B. *Curriculum Construction and Materials*

In this category six published studies were reported and one other major unpublished curriculum project is mentioned. A great many

curriculum studies are issued in the form of state, county, and city bulletins and seldom are published as research studies although they are the products of a great deal of action type or cooperative staff research. An example of this is the New York City junior high school science curriculum which has been in process for over four years, has been developed by committees of specialists, and is now in its final stage of evaluation by means of classroom tryout. Several interim staff reports have been issued. It is very likely that similar projects are being conducted in other parts of the nation although few publications, if any, report these in the professional journals.

The six published curriculum studies which are discussed here deal with experiences of pupils, principles of earth science, principles of biology, principles of soil and water conservation, health and safety misconceptions of pupils, and science in core programs. All of them, except the health and safety study, originated as doctoral thesis investigations.

In his study of the relationship between science experiences and science information of ninth year pupils, Woodburn (20) found that membership in the boy scouts, and 4H clubs contributed to students scoring higher on the Read General Science Test. Interest in reading science books was the most important factor contributing to success. Intelligence and good home life were also important factors. Students upon entering the ninth grade general science course were already familiar with a worthwhile portion of the science information customarily included in the course. Students with precocious ability in the acquisition of science information were not provided instructional experiences enabling them to maintain their relative superiority. This study employed questionnaires, tests, and personal records.

Caldwell (5) suggested 296 principles of earth sciences that were acceptable for inclusion in the science program of general education. Of these 123 were from the field of geology, 60 from physical geography (including weather and climate), 60 from astronomy, and 53 from the scientific aspects of conservation. This was achieved by analyzing published materials in earth science and then determining the relative importance of the principles by the jury technique.

McKibben (15) analyzed the principles and activities of importance for general biology courses in high schools. There were 152 significant principles selected from a source list of 300 by means of the jury technique. Related activities suited to developing understanding of the principles were found. A slight majority of the activities were found to be more appropriately performed as demonstrations.

Glidden (8) determined 66 principles within the area of soil and water conservation which should be developed at the secondary school level. This was done by analysis of available literature and

evaluation of the selected principles by experts in the field. He developed a test of information in the area and found with it that the level of mastery was not high among seniors in 33 schools tested. He concluded that more and better instruction is needed in this area.

A study was made by Mikhail (16) of how science could be integrated or fused with other courses in the form of problem areas similar to the approach used in the core program and suitable for a program of general education in the secondary schools. The author analyzed the framework of problems used in other curricula and concluded that science could contribute to thirteen problem areas. The suggested science contributions included 523 statements that were classified under seven major categories, namely, health and safety, atomic energy, conservation, human growth and development, critical thinking, communication, and hobbies.

Dzenowagis, McPherson, and Irwin(6) determined the prevalence of certain health and safety misconceptions among a group of tenth grade girls. A health inventory was given to 216 girls of the sophomore class of a high school in a Massachusetts city. Twenty-five per cent of the girls held 111 of 126 harmful health and safety misconceptions. The authors stated that the reliability of the measuring instrument was probably quite low.

Curriculum builders can find valuable material in the six studies briefly discussed above. The investigators cited have analyzed literature, checked their selections against jury judgments, administered questionnaires, inventories, and tests to arrive at certain judgments of what pupils do know or don't know, of what should be taught, and have proposed a problem type of instructional organization.

The critical question is how well will these ideas work out. The next step is the classroom try-out. Here is where the fruits of most curriculum studies are left to rot on the vine. A great deal of supplementary experimentation is necessary to validate the findings of curriculum studies of the types discussed above.

C. *Evaluative Studies*

Five studies are described in this category and they deal with the following: the influence of inheritance on achievement in science, pupils' opinions of chemistry courses and their chemistry teachers, the reading difficulty of science textbooks, the prediction of biology grades from personality traits of pupils, and the effect of a method of showing sound films on learning of principles of biology.

Anderson and Smith (1) investigated the influence of inheritance and pupil achievement in science and other academic areas. The achievement of twins was compared with that of siblings, cousins, and matched non-related pairs of individuals. A decline in common genetic

factors was accompanied by a decline in the relationship of the performance of assorted pairs. Heredity was found to be a major factor of influence on the achievement of students in subject matter learning. These conclusions were based on data concerning seven sets of twins and nine sets of twins in two parts of the overall study.

Lawrence (10) studied certain problems in articulation between high school and college chemistry instruction. A two-part questionnaire was given to a random sampling of 1000 freshman science students at Cornell University in 1953–1954. Part 1 asked the students to evaluate the various factors needed for success in first year college chemistry. Part 2 asked the students to rank the relative importance of the various traits of successful chemistry teachers.

Mallinson, Sturm, and Mallinson (13) analyzed the reading difficulty of recently published textbooks for general physical science and earth science by using a modified Flesch technique. (The validity of this technique has not been proved). Eleven physical science and seven earth science textbooks were selected. Most books were found to be too difficult for the students for whom they were written.

Gould (9) sought to determine the relationship between each of twenty personality components and achievement in ninth year biology and in general science. The personality assessment instruments used had little value in predicting any of the criteria expressed in this study. The investigator found that "the personality pattern associated with those students who elect biology as an advanced secondary-school science differs from that of students who do not elect an advance science."

Anderson, Montgomery, Smith, and Anderson (2) investigated the effect of three different methods of utilizing sound motion pictures on pupil understanding and application of scientific principles contained in these films. The investigators selected 20 sound films in which they identified 34 principles to be tested for pupil mastery. Three groups were established:

Group 1—A control group in which no films were shown or in which the teachers showed some films of their own choice.

Group 2—An experimental group in which students saw the films at intervals throughout the school year. Teachers in these classes made their own preparations for the showing of the films.

Group 3—An experimental group which saw the films at intervals throughout the school year bolstered by the emphasizing of the principles covered or stressed in each film. The teachers of these classes received the following directions with each film.

There was some evidence that Group 3, Films with-the-Principles-Stressed Method, yielded results somewhat superior to the Film Method, Group 2, and that the latter yielded results somewhat superior to a conventional method as used in the Control Method, Group 1.

D. *Programs for the Gifted Student in Science*

The realization that our national survival may well depend on our resources of gifted pupils in science has caused attention to be concentrated on this problem. A great deal of activity in school instructional programs has been initiated to identify, interest, guide, and develop the gifted science student into a practicing science worker. Industry has come forward with financial incentives for interested science students in the form of the Westinghouse Talent Search, the Shell Foundation, and numerous other scholarships. However, research studies on the gifted student have not kept pace with the hortatory articles and editorials on the need for a practical program. Four studies are reported on the gifted science pupil in this section.

Brandwein (3) in his book *The Gifted Student as Future Scientist* has made a very valuable contribution to the solution of the problem of identifying and developing gifted science students. This book is included as a reaseach work because it embodies data, case studies, reports, and rating scales which are products of over twenty years of highly successful work by Brandwein and his colleagues. The book presents six phases of the question.

1. The nature of giftedness: three factors are considered—the genetic (intelligence), the predisposing (psychological traits), and activating (environment).
2. One type of program successfully employed in stimulating the development of gifted youngsters is described,
3. A description is given of available tests and tests now being developed which seem to have promise in identifying these youngsters. Examples are Man-to-Man Rating Scales and a Rating Scale of Predisposing Factors. Four case studies based on the two scales are given.
4. A description of the behavior of these youngsters at work is presented; their high drive and tendency toward introversion; their periods of "incubation" and "illumination" as they wrestle with problems is described. Nine sample reports are given of projects of these gifted pupils.
5. The kind of teacher who seems to be successful in working with these youngsters is delineated and statistical corroboration is given.
6. Some proposals that may be useful are given. They are concerned with certain specific problems on the local level and with suggestions for action on the local, state, and national levels.

Brandwein's findings in this area have been validated by the many successful careers of gifted pupils he guided. His work must be given serious consideration whenever the question of gifted science pupils is discussed.

Witty and Bloom (19) investigated the greater use of acceleration and ability grouping with gifted pupils. They also pointed out areas of needed research revealed by a study of drop-outs among gifted students. They presented the findings of their study of 7 programs of representative high schools from a list of 24, whose graduates have shown outstanding success in science. They abstracted the 6 most

common features of the 7 most successful programs.

MacCurdy (12) analyzed all previous available studies on the characteristics of superior science students. Then, using a control group of 78 freshmen and sophomores of high IQ and 600 freshmen and sophomores who won prizes or honorable mention in the Science Talent Search for 1952 and 1953 as an experimental group, he gave both groups a 300 item questionnaire. The percentage response of each group was analyzed. Multiple choice items were analyzed by Chi Square. Items of significance at the five per cent level or more were selected as qualifying items of characteristics and background factors. It was found that certain characteristics about gifted pupils stood out sharply as for instance their personality, attitude, interests, activities, family history, associates, science teachers, and decision to study science.

The study of science fairs is included with those in the category of the gifted pupil because the science fair has evolved from the studied attempt to stimulate and draw out the best efforts of our best students. Science fairs are increasing at a remarkable rate in number and in effectiveness as a means of stimulating pupil and public interest in science education.

The entire issue of the February 1956 *High School Journal*, Volume 39, was devoted to science fairs (18). Three distinctive types of articles appeared:

1. Questionnaire studies on the reactions of and effects upon pupils who exhibited at science fairs,
2. Proposed check lists and forms for judging and rating exhibits at the science fairs,
3. Suggestions on how to set up and conduct science fairs.

The research nature of some of these articles is open to question since many of them do not include statistical data or show evidence of a rationale. However, they do report the results of many years of practical experience and so their inclusion is somewhat justifiable as action research or institutional research.

E. *The Shortage of Scientific Manpower*

The importance of the problem of the shortage of scientific manpower is very great. We will mention three reports on the subject which are based on general observations rather than statistical analysis.

Libby (11) cited as causes of the shortage of students in engineering and science poor salaries paid to teachers and the poor quality of instruction with its consequent failure to motivate and inspire students to enter the field.

Rettaliata (17) enumerated the following factors as contributory to

the shortage of candidates for scientific professions—the trend to general education courses, the shortage of qualified science teachers, the need for motivation by scholarships to talented students, the need for elementary grade talent searches, the need for better articulation of secondary science instruction with colleges and industry and the need for reappraising draft deferments.

Exton (7) gave as reasons for the shortage of scientific personnel the lag in school preparation, low science enrollments in colleges, and the science teacher shortage. Exton urged that teaching be enriched and made more stimulating, more scholarships be offered, and summertime training for both pupils and teachers be broadened.

Surveys made by industrial groups have shown that our expanding economy and population will require many more scientists than we are now training. These reports seldom appear in the educational journals but are usually published as bulletins and brochures. They are research studies to the extent that they present data. The conclusions they offer are too often based on the opinions of committees highly saturated with non-educators rather than upon research findings. Many of the recommendations are for the most part wishful thinking, viz, ask retired science workers to take up teaching, have college-trained mothers of grown children return to college two afternoons a week for courses to qualify them for science teaching, make science teaching attractive by offering as incentives to trainees the prospect of summer work and after-school work as a way to bolster their base salaries so that they can make ends meet, and the suggestion that engineers be loaned to schools to take over science classes. All of these panaceas imply that teaching requires very little if any special training and belies the need for specially trained science teachers. Too often, educators have allowed the initiative for making educational decisions to be taken over by laymen. What is needed is a joint research effort between educators and industry whereby these groups, the producers and consumers of scientific personnel, can bring their best thinking together. The educational leadership should come from educators in the form of a proposed research program on this problem. Industry will certainly support worthwhile projects with the same generosity it has shown in scholarship grants and in other ways. Furthermore, it would be good business for it to insure an adequate future supply of its most precious resource—talent.

Concluding Statement

In general the volume of research has dropped sharply in the past years. Serious thought must be given to ways of encouraging and supporting research activities in science education at the secondary school level. Six of the studies cited were based on doctoral investiga-

tions; these were by Caldwell, Glidden, Gould, McKibben, Mikhail, and Woodburn. Three reports on scientific personnel shortages and one on science fairs were included because of the crucial issues they presented rather than for their research quality.

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IMPLICATIONS OF RESEARCH IN SECONDARY SCHOOL SCIENCE EDUCATION

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Dr. Reiner has indicated the fragmentary nature of research in secondary science education over the past few years. Although the papers produced in this time have certain individual merits it does not appear likely that secondary school science will be seriously affected by them.

At several meetings of NARST there have been presented papers on needed research in science education. To a large extent these were voices crying in a wilderness. We listened to them. We agreed it would be fine to have such research, but little has been done. At our Chicago meeting it was proposed that a committee delineate problems in areas of needed research and that, in cooperation with other societies, we solicit the financial help of industry in seeking an organized, concerted solution to these problems. If our plans in this connection have not as yet materialized we should address ourselves to them once again. The low frequency and fragmentary nature of current research in secondary science education constitute an indictment against organizations concerned with science educational research.

Trends in organization, administration and current practices reveal that, in many school systems and states, science is being taught by teachers who are not certified or are otherwise unprepared to teach science at the secondary school level. The needs are obvious. Just as industry and the armed forces carry on active recruitment campaigns, so must school systems develop definite programs for encouraging high school and college students to embark on science teaching careers. Concomitantly we must make the best use of the science talent or science potential on hand in our present teaching staffs. In many instances science teaching talent is being wasted or only partially utilized because of administrative red tape. Qualified science teachers may be found teaching one or more subjects in addition to or instead of science. Active, functional in-service programs for the training and retraining of science teachers are in order on a wide scale.

To help relieve the shortage of science teachers many devices and plans are being used. Much publicity has been given to mass instructional methods involving larger classes, replacement of individual and small-group laboratory work by large-group demonstrations, closed circuit TV, use of expert teachers assisted by so-called teacher-aides (reminiscent of monitorial systems employed many years ago), increased use of audio-visual materials. Some educators rationalized that audio-visual materials prepared by experts may substitute in

some degree for the expert science teacher. Is this a valid contention? What are the needs for research in this area? How effective are various devices and technics for mass instruction? Are stream-lined lecture-demonstration methods of teaching science as effective as other methods for teaching the average student, the gifted student? What kind of training should a teacher of chemistry, physics, biology or earth science have today? How much science content; how much science pedagogy should be incorporated in the education of science teachers?

There is a need for coordination among the curriculum makers, the test constructors and evaluators, the administrators, the specialists and the general practitioners—the teachers. Frequently these groups carry on separately in their own spheres of activity without consultation or cooperation with the other groups. A two-year course in physical science, centered around waves and wave motion in physics and around atoms and atomic changes in chemistry, is being developed at one of our universities by some of the nation's best scientific minds. Is this the best way to develop a course in secondary school science? Should there be provided a firm foundation in the physical and biological sciences in the form of separate courses in each of the sciences or in fused or integrated courses? Has the traditional organization of science courses proven its worth or do we need a completely new perspective and orientation?

Above all needs is the need for intelligent, informed, creative leadership in science education to function in developing new or modified curricula cooperatively, in recruitment programs for new teachers, in re-training present teachers, in developing responsibility and leadership among teacher groups and in individual teachers, in stimulating the production of books, materials of instruction and audio-visual aids, in coordinating the various facets of educational programs in science so that unity, purpose and articulation characterize them, and lastly in ascertaining the needs of a school system in science education and determining the role that research can play in meeting some of these needs. Following the definition of science education research problems there would be cooperative planning with teachers, supervisors, administrators and specialists for such research. Our colleges, universities and teacher training institutions can do much to identify and nurture potential leadership in their undergraduate and graduate programs. In large school systems there are many well-trained, creative science teachers with high leadership potential who are undiscovered or ignored. Definite steps should be taken to identify these teachers and to make use of their talents.

Are we so concerned about the education of future scientists that we are neglecting or minimizing the contributions of the humanities to secondary education? Already a hue and cry is being raised by

those who have a premonition that the present focus of attention on science education will lead to the overlooking of some of the basic aims of secondary education. The need for a balanced program of secondary education is in order. This program should function to elevate the general educational level of our youth in all areas and at the same time should provide for special interests and capacities of youth in specific areas including science.

In the area of curriculum construction and materials Dr. Reiner has mentioned the on-going production of state, county and city bulletins on secondary science which are not the products of research. This type of production is wholesome. It reflects the concern of school systems for keeping their science programs in harmony with the times. There is a need for classroom testing of these materials which are frequently conceived by a small group of experts.

Woodburn has concluded from his research that instruction in ninth grade general science tends to close the gap between those who enter with a minimum and a maximum amount of prior science instruction. Thus a student showing precocious ability in the acquisition of science information is not provided instructional experience enabling him to maintain his relative superiority. We may imply from this that if a separate learning track geared to his abilities were provided for the precocious student he could capitalize on his abilities and not only maintain but extend his superiority over the mediocre of pedestrian student. There is a need, therefore, for providing for more individualization of science instruction by organizing homogeneous ability groups with special courses of study, special methodologies, and perhaps, with specially trained teachers for each type of group. The problems of teaching science to average and retarded pupils are to some extent distinct from the problems of teaching science to the gifted.

Studies on core curricula indicate that effective use of problem areas in science can be made in planning core programs. Are core curricula best for all pupils? Is there a need for an extensive study to assess conflicting and contending points of view and philosophies in secondary education and, in particular, to determine the most functional context in which science can be taught to meet the needs of all pupils at each level of secondary education?

Let us turn now to the problem of the gifted pupil in science. Various ways of identifying him have been adduced. The nature of giftedness in pupils has been described together with those characteristics of teachers that promote the education of the gifted. What problems still face us? Should the gifted pupil in science be required to take the same kind of curricular offering in science as the average student? Does enrichment of the curriculum provide a satisfactory

solution? May the instructional time devoted to basic science courses at the secondary level be abbreviated for the bright student and the time saved be given over to work concerned with the furthering of his special interests? For example, instead of the traditional five periods per week, could the basic work involve three periods or four with the periods saved being devoted to special project work, research or advanced readings? What elective courses in science shall we offer to the gifted? At the High School of Science there is a large roster of courses in the sciences. In biology, pupils may elect courses in laboratory technics, field biology and home technology. To what extent should encouragement be given to the program of admission to college with advanced standing? It is possible now, in some high schools, for senior students to take one to four college courses and to receive college credit for them. Is there real advantage to the individual and to society in acceleration of the gifted in science?

Science Fairs, Science Talent Searches, Science scholarships sponsored by government and private agencies are encouraging the gifted in science to pursue their interests. What technics for selection of winners are being used? How valid are they? What degree of correlation is there between school estimates of science talent and the selections made in contests or by tests? Much criticism has been levelled against some current selection practices. Research could probably help fashion better instruments and methods for identifying top science talent.

The demand by industry for scientific manpower has prompted the encouragement of science education in a variety of ways. Industry is pouring thousands of dollars into the production of free materials, scholarships and science teacher training programs. The need for effective liaison between industry and education is apparent. Some progress has been made in this connection but not enough.

Has sufficient thought been given to apprenticeships in science for secondary school youth? During the days when guilds flourished, young men, aspiring to a given type of life work, were apprenticed to masters who taught them the art and skills of the trade. To what extent would it be desirable to have outstanding secondary school science talent apprenticed to scientists in colleges, universities, government service and industry?

What kinds of facilities are needed to house and nurture science talent? The new High School of Science will have biology, chemistry and physics laboratories and separate project rooms for each of these areas. In addition there will be special shops where pupils will learn basic manual and machine skills, photographic dark rooms, two greenhouses, a planetarium, a weather observatory and special laboratories for elective courses in biological and physical sciences. School

systems throughout the country should derive some benefit from the tremendous expenditure of time, energy and creative planning involved in developing blue prints for the new High School of Science.

And now, lastly, what type of school organization should be developed or provided for secondary school science talent? Can the usual heterogeneous type of secondary school provide adequately for its science talent through special curricula, honors courses, elective courses, science tracks, co- and extra-curricular science programs? Does this type of school have a teaching staff capable of doing an effective job of developing and nurturing science talent?

How feasible is the suggestion that there be created regional High Schools of Science throughout the country? These would draw science talent from relatively large areas into a physical and educational environment specially designed for their needs, interests and capacities. The curriculum of these schools, like that of the New York City High School of Science, would be rich in its offerings in the humanities as well as in science. The salaries offered at these schools would be sufficiently high to attract superior teachers of science and the humanities. Regional schools of science would establish close liaison with industry locally and nationally.

Many of the problems raised in this paper are not conducive to solution by the application of educational research technics. However where there are fundamental problems of secondary school science for which answers may be found through research then it is the responsibility of the concerned agents of our society, educators and men of industry, to plan together and to sponsor research activities and programs structured to provide the answers.

SURVEY OF RESEARCH IN COLLEGE LEVEL GENERAL EDUCATION SCIENCE

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This is a non-technical summary of research in college level general education science for the period August 1955–56; it constitutes a progress report of the College Level Committee of the NARST. A technical documented report of the work of this Committee was presented at the annual meeting of NARST in Atlantic City, during February, 1957.

The studies involved the Committee in analysis of 46 journals, and abstracts, gathered from the United States Office of Education. The following titles are indicative of the wide range of these studies:

curriculum studies pertaining to courses for general education, implications of scientific thinking for laboratory procedures, organization of laboratory programs in general education, science, science for retarded students, science education programs in teachers colleges and for theological students, conservation education, and how to vitalize biology with live animal projects; *textbook analyses* of the treatment of ionization in chemistry texts, desired competencies for prospective teachers, and the readability of biology texts; *teacher training studies* of the scientific backgrounds and competencies of prospective teachers, and what administrators want in the training of science teachers compared with their actual training; *group process studies* of the characteristics of superior science students and their sub-groups, the effect of multiple instruction on learning, the project method, use of biology work centers, inductive-deductive methods, laboratory work in physics, group study versus lecture-demonstration, and uses of diversity in civil discourse; *characteristics of successful students* including studies of grades made by students who had high school science and those who did not, and the relation of success in college science to science and mathematics backgrounds in the secondary schools; *elements of scientific method studies* including scientific attitudes, and explanations of college students in terms of their concern for animism, anthropomorphism, personification, and the like.

Some of the current research serves to foster the development of new and exciting practices, some serves to challenge current practice, and much is concerned with sustaining and strengthening present practice. While it is difficult to specify the degree to which any area of research influences another, the suspicion lingers that the execution of science education research at the college level is not suitably coordinated with the practice. If it is true that there is a lag between research and practice in the field, this may be due to a lack of "readiness" to accept science education research studies which are available, or to a considerable ignorance that such research studies have been conducted and published. There is also a continued isolation of "science educators" from educators *per se*, from other college teachers, and from the "pure" scientists. There is some justification for the belief that whatever changes as may be occurring in science education are probably not geared to the research in the field, but to other societal factors.

Analysis of the studies reviewed indicates a somewhat disconnected approach to science education research. In fact, if one utilized the current research studies as one base for developing an "experiential definition" of college level science education research he would be struck at the concern for curriculum revision. That is, many of the studies are concerned with all of those experiences that a student has,

or is likely to have while in college, or with the effects of pre-college experiences on the college science experience, and upon subsequent behavior. So defined, science education research at the college level would be seen to be primarily concerned with that which has, will, or should have a significant bearing on the learning-behavioral changes of those students who participate in science courses.

Much of the current research is concerned with the identification and delineation of objectives which are stated as principles, generalizations, and/or concepts. These studies attempt to select and describe what should be taught and what could be taught. The source of much of the data is found in expert opinion, social statistics, and analysis of newspaper, magazine, and textbook content. This type of research tends to be subject-centered, and the sources of the data tend to be secondary rather than primary. Objectives (stated as principles, generalizations, and the like) are thought of as specific goals which will be useful in life. Another tendency is to point out the weaknesses of the early studies, both in their technical composition, design, technical treatment of data, and their failure to state or recognize the basic assumptions involved.

There has been a shift to emphasis on the learning process, although the research involved continues to lack precision, is piecemeal, repetitive, specialized and lacking in pertinence in-so-far as philosophical and modern educational psychology are concerned. This becomes the more striking when it is seen that there are so few new or highly imaginative research designs and techniques used and too little consideration of a philosophy of science education, or of value determination in the use of statistics. Further, there has been little attention paid to action and cooperative research for the progressive development of research and experimental designs, especially in the universities granting the higher degrees.

At the national level there has been a general sweep towards general education science courses. The scholarly analysis constituting the Harvard report, ***General Education in a Free Society*** has not been followed by experimental and other scientific evidences which would support the postulations which such report made. While laying bare the problems facing modern American secondary schools and colleges, the "new" courses in general education science have not materially departed from the traditional prescribed watered down "content but no laboratory" courses which they presumably replaced. There has been no counterpart, at the college level, of the ***Eight Year Study***, or of the Michigan, Illinois, and Wisconsin studies. There can be found only a few instances of serious scientific investigation of the nature and structure of the "new" courses and these apply to specific isolated localized situations.

Despite this general lack of a secure-all conceptual framework and data secured by experimental evidence, there has occurred a gradual infiltration into college level science education of the "needs" studies developed at the elementary school levels. Needs are sometimes classified as social-psychological or personality needs, and sometimes as organic needs. The trend seems to represent a drive, on the part of some investigators, to establish absolute essentials for human survival and program in a changing society, restated as effective participation in the democratic society. Emphasis in such studies is upon problem-solving, attitude formation, elements of the scientific method(s), and the democratic group process. The base is identification and satisfaction of the personal-social needs of students at whatever level of performance they appear to be capable of. The essential character of these studies is their concern for what should, or ought to, be done with subject matter and instrumental skills when the especial concern and orientation is for individual interests and needs of the individual student. This problem is of increasing concern to many college level science educators.

Apparently college staffs are still confused as to how to deal with individual differences, due, no doubt, to their desire to "maintain standards," operate under accreditation practices, and meet certification requirements. What little research exists in the area of individual differences at the college level indicates a rather wide acceptance of the wide range of abilities or traits and performance levels among the individual students, but continued rejection of the practical impossibility of ability groupings. There are, further, a number of striking studies on the relation between pre-college science and college science experiences, and startling studies dealing with the success of the superior student in science.

There has emerged, as a result, some research in group atmosphere, group action, and human relations. A few science education researchers are moving into research dealing with the effect of group-decision-making, role and function of leaders, and the extent of group resistance to changed roles and functions as factors in moving students to new and higher levels of learning. The literature deals more and more with the necessity for cooperative planning, and emphasis on needs, interests, and problems of students as factors in the learning process. There is increased concern for democratic procedures, leadership behaviors, creative imagination, and scientific attitudes and habits of thinking, for improving learning.

However, there is, as yet, no counterpart on the college level, of the series of child development and growth studies, even though some college level studies begin to deal with maturational levels of college students as to what they want to, and will learn. Some of the current

studies concern themselves with what college students need to know about science in order to meet their internal needs, or their personal needs, or their social needs, as well as their external social-environmental needs. Other studies concern themselves with needs for the formation of productive partnerships in planning for learning, and the impact of emotions on the learning process. However, few of these studies concern themselves with the relatively subtle changes which a shift in the practice of learning evokes in students; there is continued concern for the gross aspects of the mastery of subject-matter, knowledge, and informational shifts, but not enough concern for attitude and other behavioral changes, or the relation of prejudices of various kinds to learning.

The studies which constituted the base for this report are, to a large extent, representative of research devoted to the study of observable changes in behavior (the gross changes), classification of these observables to each other. This has taken the form of curriculum revision studies, classification of principles, needs analyses, analyses, maturational studies, role and role playing, and concern for educational philosophy and objectives.

From the preceding discussion it may be seen that the research currently reviewed includes studies from a wide range of areas which are apparently unrelated. It also appears that some of the contemporary research is different from that of the past. It may be said, then, that some of the current research in science education is in the unsatisfactory position of attempting to ascertain or identify an undetermined responsibility for unknown conditions affecting unknown behavior. To clear up this state of affairs there is need for re-definition of the goals of science education research. This conclusion stems from the belief that the observance of bit-by-bit, day-to-day conditions under which learning takes place requires a different approach to the gross observance of change in student behavior. More specifically, it now appears that what is required are: a) investigations of the conditions under which new behavior is acquired; b) investigations of the conditions under which present behavior is maintained or eliminated; and c) investigations of the conditions under which continuing behavior is developed or shaped or structured. We have a considerable literature in the first of these areas, but too little in the second or third areas.

It now appears that science education research at the college level is in need of more fundamental concern for experimental determinations and verifications. The correlational and scholarly studies should continue to be regarded as exploratory and preliminary, while experimental investigation demonstrates that the independent variable is accompanied by observable variation in the dependent variable. To

move, for instance, from "needs" (which represent inner states of the organism) to manipulation of the conditions (curriculum and the learning process) under which these needs are to be satisfied, demands a further consideration of the variables of which such behavior is a function. Hence, it is concluded that science education research at the college level, both basic and applied, must make further progress in an increasing number of fields, and that a systematic relation must develop concurrently between basic research and the application of such research in the practice of teaching.

IMPLICATIONS OF RESEARCH IN COLLEGE GENERAL EDUCATION SCIENCE

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Dr. Weaver, in his paper, remarks that, "*Much of the current research is concerned with the identification and delinaetion of objectives which are stated as principles, generalizations and/or concepts. These studies attempt to select and describe what should be taught and what could be taught.*"

It has been my task as a member of the College Level Committee of NARST for several years to read and to evaluate research papers in many journals. In the last few years, the journals have carried numerous articles on new courses purporting to serve general education ends. One such course in the physical sciences involved a laboratory study of the following topics in a period of approximately 14 weeks—"spontaneous" processes and natural causes, optical instruments, uniformly accelerated motion, velocity vectors and gravity, air pressure and its measurement, air pressure effects, buoyancy, human conduction of electricity, electromagnetic conduction, electrolysis, reduction, oxidation, titration and synthetic or commercial chemicals.

One finds it extremely difficult to reconcile such a course content with any of the following points of view.

Professor Ernest Nagel of Columbia said a few years ago that, " . . . the conception that general courses in science should supply an encyclopedic compendium of useful knowledge must be abandoned. The essential point is that the materials to be included for study must be highly selected with a double end in view: to make the student competently familiar with some representative experimental and theoretical analyses of the natural sciences, and to provide him with clear examples of the operation of scientific method."[1]

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[1] Nagel, E. "The Methods of Science: What Are They? Can They Be Taught?" *Scientific Monthly*, 70, No 1, January 1950, p. 19.

The committee on goals of the President's Commission on Higher Education said, . . . "What is needed . . . is the integration of the significant methods and findings of the natural sciences into a comprehensive synthesis that will bring to the general student understanding of the fundamental nature of the physical world in which he lives and of the skills by which this nature is discerned."[2]

Professor Eric Rogers of Princeton has said, "The new courses should mediate between the layman and the scientist, between a classical culture and a scientific civilization. They cannot do this just by pouring in scientific information or formal training. They must try to give a sympathetic understanding of science and the way scientific work is done."[3]

Professor Joseph Schwab of the College of The University of Chicago has said more recently, " . . . one particular theory concerning the particular particles, masses, charges, and motions which constitute the atom, may, for instance, have a very limited life and a limited applicability; but the technique of seeking explanations of physical and chemical phenomena in terms of particles of some mass, charge and motion will persist as long as theories of this kind have their usefulness and continue to be capable of revision and enlargement to encompass new phenomena."[4]

I can go on quoting from numerous other sources on the aims of general education courses in science and on methods of achieving the aims. However, I believe that the point is already made. There is really no great need for conducting research directed towards determining objectives for science courses in programs of general education. These have been stated well and often.

It merely remains for us to read them or re-read them and to use them properly.

Another point made by Dr. Weaver is that, "*The scholarly analysis constituting the Harvard Report, 'General Education in a Free Society,' has not been followed by experimental and other scientific evidences that would support the postulations which such report made . . . the 'new' courses in general education science have not materially departed from the traditional prescribed watered down 'content but no laboratory' courses which they replaced. . . . There can be found only a few instances of serious scientific investigation of the nature and structure of the 'new' courses and these apply to specific isolated localized situations.*"

I am in complete agreement with these observations of my colleague.

[2] "Higher Education for American Democracy," Vol. 1, *Establishing the Goals*, A Report of the President's Commission on Higher Educaton, Washington, December 1947, p. 52.

[3] Rogers, E. M. "The Good Name of Science: A Discussion of Science Courses for General Education in College," *Science*, 110, December 9, 1949, p. 599.

[4] Schwab, J. J. "Science and Civil Discourse: The Uses of Diversity," *Journal of General Education*, 9, No. 3, April 1956, p. 132.

We must realize that a great part of the study and research in this area will always concern, "specific, isolated and localized situations."

I hope that the general education movement will be a successful one. If it is, I do not believe that one evidence of its success will be a uniform curriculum that can be adequately taught by using any one of a dozen textbooks.

The better courses in these programs have been characterized by originality, freshness, newness, changeability, and experimentation. The construction of these courses has given some of the outstanding minds in science teaching a chance to try new approaches, new methods of teaching, new curriculum materials, and new evaluation devices. And in the programs with which I am familiar there have been frequent curriculum revisions and substitutions of one set of materials for a completely new one. It is doubtful if there ever will evolve, through such an approach, the nationwide uniformity seen in the traditional first year course in any of the categorized sciences.

The best efforts in curriculum construction and in evaluation, it seems to me, will always be in "specific, isolated, localized situations."

I also agree with Dr. Weaver when he says that, "*It now appears that science education research at the college level is in need of more fundamental concern for experimental determinations and verifications . . .* " and that such research "*is not suitably coordinated with the practice.*"

I would like to indicate a few areas in which I believe that studies would be very useful.

It is undoubtedly true that general education courses in science are not as successful as they might be because they are not accepted by a great many teachers of science. What is the reason for this failure of general education courses to "sell"? Does it mean that many of us are entirely satisfied with the traditional courses as they stand? Is the opposition largely on the basis of "general principles"? Or is it the result of a lethargy and lack of desire to change something that seems to be progressing well? The reason certainly cannot be that general education courses have been shown to be inferior to the traditional courses in meeting objectives, in satisfying the needs of students, or in any other way. This is the kind of information that we do not have, but that we sorely need.

Other questions to which we need answers are the following:

Are most of our so-called general education courses in science actually traditional survey courses characterized by the teaching of sequence after sequence of the conclusions of science?

To what degree have genuine education courses in science replaced the formal introductory science courses for non-science majors? for science majors?

Do general education courses have to be required courses in order to be successful from the viewpoint of continued, unslacking, or perhaps, even increasing, registration?

Is there a specific or general pattern which makes for a more ready acceptance of general education courses by both faculty and students?

Where are the better and/or the more successful general education courses in science being offered?

We are frequently permitted to observe the birth and childhood of new courses for which great hopes are held. We need more data on the maturing and on the demise of many of these courses.

We are suffering from a paucity of reliable information in the science in general education area. I believe that we need three varieties of studies—one almost purely statistical in nature, another experimental, and the third patterned after Alexis deTocqueville's *Democracy in America*. This highly regarded political and sociological study of more than 100 years ago bears little resemblance to most of the studies in our own field. It is also quite different from Earl McGrath's excellent compilation, *Science in General Education* of a few years ago. We need a comprehensively descriptive and critically analytical study of the status of general education courses in our colleges today.

We must exercise more care in the supervision of research in science education and in the publishing of such research. In going through some of the published papers of the past year I found some studies purporting to be experimental in which no control was used; another in which neither the validity nor the reliability of the evaluation material was determined; another in which test items were used in a succession of years without the application of the simplest of item analysis procedures. I read several studies characterized by a very large amount of highly specialized statistical treatment that I am certain would not be easily comprehended by the average reader. It is my belief that in many cases a paper that might otherwise be significant is overlooked because of its overpowering collection of tables and components of the Greek and English alphabets and Arabic and Roman numerals in various combinations. I react strongly against the use of highly technical statistical treatment of a problem in science education merely for the purpose of giving the solution an apparent validity. Very frequently, another effect is actually achieved.

In summary, my stand is that we are not ready to make valid judgements of the effectiveness and usefulness of general education courses in science until we have a great deal more data than we now have.

ADDITION AND SUBTRACTION WITH LINEAR SCALES AS AN INTRODUCTION TO STUDY OF THE SLIDE RULE

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The slide rule is a popular topic with teachers of mathematics. It captures the imagination of the bored student by removing the drudgery of computation. It also helps the teacher separate arithmetic from mathematics.

Courses in the use of the slide rule are common at the college level, and there are several good texts available. There are slide rule manuals and large classroom size rules for demonstration, but for most students there is still the initial hurdle of understanding the principle of the rule and learning to read it.

A slide rule is a rather mysterious device when used for the first time, and any technique which helps to dispel the mystery is of value. Furthermore, the slide rule involves skill in reading a scale, the use of a non-uniform scale, and the use of logarithms. Anything which makes it possible to take one new idea at a time has learning value.

It is, of course, possible for someone to learn the use of the slide rule in memorized and empirical fashion by the use of a rigid set of rules, but this approach would be hard to justify in any but a trade school. Most teachers of mathematics prefer the approach which requires some knowledge of exponents and the properties of logarithms. The particular technique described here provides both scale reading drill and understanding of principle.

There is nothing novel about the use of other scales as a preliminary to the learning of the slide rule. There are methods cited in the literature by which the student makes his own paper slide rule (1), makes one with semi-logarithmic coordinate paper (2) and practices the use of scales with an ordinary ruler (3). The virtue of this technique is that it uses common classroom tools to make a useful and functioning addition-subtraction rule.

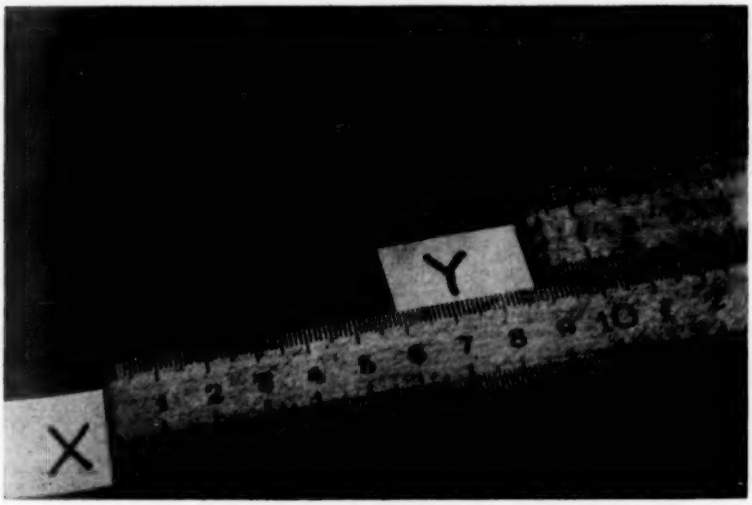
A slide rule performs its operations by adding, subtracting, and equating lengths on a scale. If the scale is a logarithmic one, these processes become multiplication and division. Historically, this was done with only one logarithmic scale and dividers or some other representation of distance used against this single scale.

These fundamental processes can be duplicated with a pair of meter sticks, and any number of addition and subtraction problems can be done. Meter sticks are infinitely superior to ordinary rulers because they are laid out in powers of ten and correspond to the number system. Twelve inch rulers subdivided into sixteenths are a

clumsy and confusing substitute, and they can only be used in the crudest way.

Addition, subtraction, and meter sticks are all familiar. The first thing to be mastered is to read the scales accurately. The names of the units can be ignored.

In a typical preliminary exercise, it might be well to have members of the class merely pick out numbers on one rule and to practice shifting the decimal point mentally. If the 148 millimeter point on the scale is called successively 0.148, 14.8, and 14,800, then what numbers would exist at the 521 millimeter point? The limitation of 1000 millimeters on the scale is no more a barrier here than the absence of unit scale divisions on a slide rule. The millimeter subdivisions can be estimated in tenths, and four significant figures are available. The student now gets some much needed experience in estimating the tenth part of a scale division. At this point he can also be asked to make the important decisions of rounding off numbers with too many significant figures for his four figure scale and then representing his second figure on the scale in a corresponding number of significant figures. The mental agility needed to leap from one number to another when both are represented on a scale is a fundamental slide rule need.



A meter stick "slide rule."

The next step might well be addition with the use of two meter sticks, calling them the *X* and *Y* scales. As shown in the accompanying photograph, the "index" of the *Y* scale is placed over the 90 on

the X scale, and then the number 24 is located on the Y scale. Reading down, the sum of 114 is read off the X scale. It might be well to try this several times, taking the number on the X scale as 900, 0.9, or 9 and then making the proper choice of the corresponding value of the 24 on the Y scale.

A limitation of this teaching technique exists in the preservation of place value so critical to addition and subtraction. Since the meter stick has 10^3 millimeters on the face of it, it follows that numbers differing by two places (a factor of 100) may be easily added and subtracted. Thus combinations like $844+8.6$, and $56,200-400$ are easily handled. Combinations like $921+0.14$ or $0.657-0.0007$ approach the limitations of the method. It might be well in a slide rule course to bring up this limitation of the meter sticks after the initial hurdles of the rule are over. By careful selection of exercises the matter need not come up until the class is ready. Students usually do not have to multiply $68,240\times 0.000167$ as a first exercise on the logarithmic rule either.

Subtraction can be just the reverse of addition. Find the minuend on the X scale, put the subtrahend directly over it, and then read the difference where the index of the Y scale meets the X scale. The only new idea needed for the use of a logarithmic scale is to be able to read the answer on either end of the upper scale. The upper scale with the meter sticks will only move to the left for an unlikely negative value.

Like all kinds of teaching by analogy, this method can not be pursued too far, but it will serve as an easy introduction. The amount of time devoted to this kind of preliminary work will vary with the course and institution. As a personal experience, I found that one or two class sessions with the meter sticks were enough to prepare a class for slide rule exercises. As a practical point, it gives the teacher an activity to carry on during the first class sessions when the students do not have slide rules.

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3. Peak, Philip, "The Slide Rule in Junior High School Mathematics," School Science and Mathematics, 46, 821. Dec. 1946.

FLU EPIDEMIC PROBABLE THIS WINTER, PHS SAYS

The Public Health Service has asked the nation's six producers of flu vaccine to have at least 60,000,000 doses ready by Feb. 1.

An influenza epidemic that will sweep the U. S. from coast to coast is a definite probability and the vaccine is the only preventive measure that exists.

The drug companies have gone on a crash program with two or three production shifts working seven days a week to get the vaccine ready.

DEVELOPING SUCCESS QUALITIES IN OUR FUTURE SCIENTISTS AND MATHEMATICIANS

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A thorough knowledge of subject matter is essential. But, what other personal characteristics should our schools attempt to cultivate in pupils with the potential to become future scientists or mathematicians? What qualities best provide for the optimal development and future success of pupils who will have important roles in the future of our nation? How can these valued qualities be encouraged and cultivated in classrooms today?

Most authorities agree that the following qualities, traits, and characteristics are ones of particular value to individuals interested in scientific and mathematical endeavors, for the success the person has in these fields is undoubtedly closely correlated to the degree and extent to which the individual possesses them. They are: 1) Dependability, 2) Goal-directed Activity, 3) Experimentation, 4) Human Relationships, 5) Logical Thinking, 6) Creativity, 7)Self-expression, 8) Patience, 9) Modesty, and 10) Alertness. The more of these qualities that our schools can develop in youth, the farther these people will likely go in science and mathematics. While assuring the student a thorough foundation in the subject material at hand, paramount consideration must be given to the overall development of the pupil in the ten areas listed above.

One could hardly exhaust all of the activities, methods, techniques, and procedures teachers could use in fostering development in these ten important areas. A few of the successful activities, practices, and techniques teachers have found valuable for such development will follow in this article.

I. Dependability

Dependability is prized in technical work, for effort, time, and money can be lost through someone's carelessness or lack of responsibility. Pupils need to be made aware of the importance of dependable results. In order to develop a sense of reliability, pupils need to participate in activities which involve authority, accuracy, and responsibility.

> In other words, the mathematician in industry, to the extent to which he functions as a mathematician, is a consultant not a project man. . . . He must be a man of outstanding ability. No one wants the advice of mediocrity.[1]

Suggested school activities for fostering dependability:

1. *Cooperative Planning*—Whenever possible, classroom activity

[1] Price, G. Baley, "A Mathematics Program for the Able." *The Mathematics Teacher*, XXXXIV (October 1951), p. 371.

should be planned cooperatively by pupils and teachers. If the pupil has an active part in planning the objectives and purposes of classroom activity, he will be more likely to take a more active interest in the outcome of the activity. Cooperative group work and cooperative evaluation of the activity, too, make for more dependable results.

2. *Daily Schedule*—Teachers should encourage each class member to prepare daily schedules which bring about a planned budgeting of time and effort. Too, if class activities are carefully planned, students are more apt to become appreciative of the fact that planned activity makes for more dependable results.

3. *Delegating Responsibility*—Teachers can help foster and develop dependability in pupils by encouraging each class member to join committees, clubs, and organizations, for practice in carrying out assigned duties and responsibilities. In the science and mathematics classroom, teachers should delegate responsibility to individuals in as many ways as possible. Often students can be asked to care for classroom equipment, supplementary materials, and so forth. Teachers can ask pupils to head discussion groups, conduct special experiments, evaluate plans and procedures for future units of work, or prepare special reports for the class about some phase of the work at hand. Teachers should insist that each class project be carefully planned, conducted, and evaluated in order that the most dependable results prevail.

4. *Checking Results*—Evaluating conclusions and checking results are all-important factors in bringing about dependable results. Checking procedures in mathematical computations should be emphasized by the teacher. Careless errors cannot be tolerated in technical work. Hence, carelessness should not be tolerated in our classrooms.

II. Goal-Directed Activity

Problem-solving in science and mathematics is a planned procedure directed toward certain goals and objectives. Investigation and experimentation are of value to the scientist and mathematician, but guesswork and aimless prodding are of little value. Teachers can develop a realization of the importance of goal-directed activity in their pupils in many ways. It seems important that teachers and pupils plan classroom work together; in this way many activities are directly planned in the light of pupils' interests, needs, and prior knowledge. Too, through cooperative planning, pupils are more apt to become aware of the importance of planned, goal-directed activity.

Suggested school activities for fostering goal-directed activity:

1. Cooperative teacher-pupil planning, execution, and evaluation of classroom activities.

2. Develop in as many activities as possible an appreciation for and an understanding of the use of the scientific method of problem solving. Constantly keep pupils aware of the purposes of present classroom activities; continually evaluate activities in terms of set goals and objectives.

3. *Varied Approaches*—Goals in science and mathematics work may be achieved through the use of a variety of activities. Reading, experimentation, observation, research, questioning, and construction are all valuable methods of approach. The classroom, therefore, must be suitable for a variety of experiences involving both a freedom of choice of method and an atmosphere conducive to learning.

III. Experimentation

Little need be said of the importance of exploration and experimentation in scientific fields. The classroom activities must allow freedom, time, and opportunity to explore—explore and experiment with new ideas, methods, and procedures.

1. *Purposeful Experimentation*—In order that experiments in science and mathematics be most meaningful they should be used to: "(1) help pupils solve a problem by applying the findings and (2) make an important idea more easily and thoroughly understood."[2]

2. *Proper Classroom Atmosphere*—Classroom facilities and equipment can help or hinder activities involving experimentation. Too, solutions to problems in science and mathematics do not always come easily. First attempts by pupils to solve problems in mathematics and science often fail; it would seem important that teachers be extremely cautious about rushing to the pupil's aid even after one, two, or three failures to solve the problem at hand. Instead, teachers should emphasize the fact that work in science and mathematics often results in a failure to achieve set goals. Yet, something is learned in each attempt to solve a problem. Think of the many failures which occurred in the search for a polio cure. Although a decisive solution to the problem at hand may not be found by the student, an appreciation for patience, hard work, and other valued qualities may be kindled in these prospective scientific leaders.

IV. Human Relationships

Scientists and mathematicians in their everyday tasks must deal with *people* as well as facts, figures, and equipment. Success in technical fields today depends a great deal on the person's ability to work and cooperate with others.

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[2] Blough, Glenn O. "Experimenting—For What Purpose?" *Metropolitan Detroit Science Review*, XVII (February, 1957), 29–30.

Teachers can help develop pupils' abilities to work with others by:

1. Encouraging group as well as individual activities in the classroom.
2. Encouraging pupils to share ideas, opinions, solutions, and methods with others in the classroom.
3. Planning activities which require group action and group cooperation.
4. Promoting a democratic atmosphere in the classroom in which each participant plans, carries out, and evaluates activities of the day. In this way pupils learn to appreciate the value of cooperative planning and enjoy together their accomplishments, successes, and progress.

V. Logical Thinking

Closely related to goal-directed activity is the development of logical thinking on the part of all pupils engaged in work in science and mathematics in our high schools, for both involve the important "scientific approach" to problem solving. Teachers can help develop the process of logical thinking in pupils in many ways. It would seem important that all teachers recall the important psychological factors of learning so that they can teach in terms of the interests, needs, and motivation that their pupils have presently. Defining the problem, gathering facts, consulting authorities and references, reaching tentative solutions, checking results, reaching final solutions and the follow-up are all part of this important logical thinking approach.

Suggested activities for developing logical thinking:

1. Encourage, teach, and use the scientific method of problem solving whenever possible in classroom activities.
2. Provide activities such as discussions, writing activities, experimentation, and others which provide opportunities for developing logical thinking.
3. Teachers should take advantage of the many opportunities in their own teaching activities to illustrate logical thinking in their own approach to problem solving—set an example of good thinking.

VI. Creativity

Fostering creativity in pupils with potential in science and mathematics is indeed an important project for our high schools. The technical world of today is a creative world—new ideas, methods, procedures, products, and techniques are continuously being developed. Future mathematicians and scientists need to be creative in order that they enjoy optimum success in these fields.

Suggested activities for fostering creativity:

1. Encourage new ideas, opinions, and methods of approach in classroom activities.

2. Use a variety of materials and procedures in classroom activities. Don't be a "the book says" teacher.

3. Promote an atmosphere which is conducive to freedom of expression and exchange of ideas. Be creative in your own approach to teaching.

VII. Self-Expression

Technical workers of today are called upon frequently to express their ideas, findings, or knowledge in writing or through speaking. New information, ideas, and progress must be conveyed to both professional and lay groups of various kinds. The process of passing on scientific information to others in written form or through the spoken word is indeed important in modern times. Schools can play important roles in this area by encouraging activities which will lead to the optimum development of each pupil's self-expression.

Suggested activities for fostering self-expression:

1. Encourage good reading, speaking, and writing habits in all school activities.

2. Promote an appreciation for effective expression, correct word usage, and exact grammar.

3. Provide opportunities for self-expression through oral discussion, individual reports both oral and written, research reports, laboratory notebooks, and other forms of oral and written language.

4. Place emphasis on work in vocabulary; stress terms peculiar to work in the fields of science and mathematics.

VIII. Patience

As was mentioned earlier, solutions to problems in science and mathematics do not always come easily. Pupils need to develop persistence and patience in regard to the solutions of problems in any field of endeavor. Failure to get immediate, correct answers to problems is often frustrating and discouraging. Pupils need to be made aware of the fact that scientists and mathematicians are even now in the pursuit of answers to problems that have evaded others for years and years. Yet, they do not give up. Patience is not only an asset in scientific work, it is a necessity.

Suggested activities for fostering patience in pupils:

1. Develop the right attitude toward failure. We learn much each time we fail. Teach for an appreciation of dependable results, but

emphasize the fact that work in science and mathematics is not easy in all cases. A person may fail many times in the attempt to find certain solutions, but when success finally comes it is usually worth all the effort and more.

2. Encourage patience and a sense of persistence in regular classroom and school activities. Be cautious about solving problems for those pupils who have made little effort on their own or who may be on the verge of solving the problem themselves.

3. Set an example of patience and persistence in your own teaching. Show that scientific work depends upon dependable results, but patience and hard work is usually requisite to the solutions to most of the problems in these technical fields.

IX. Modesty

Isaac Newton is said to have remarked, "If I have seen a little farther than others it is because I have stood on the shoulders of giants." The successful scientist or mathematician realizes that there is much to be learned about the world; much that he himself must learn in order to keep abreast of current problems; and much that he cannot do without the help and assistance of others. The true scientist or mathematician is most generally naturally modest in regard to his own accomplishments, for he realizes that what he has accomplished has depended upon what others have done before him, what others have done to help him and what others will do to continue the research for even further refinement of the accomplishments he may have made.

Suggested activities for fostering modesty:

1. Develop the practice of giving credit where credit is due. Encourage and praise work worthy of such merit, but point out the fact that new problems may now have to be faced in the light of the solutions reached.

2. Set an example yourself in regard to modesty.

3. Encourage continuous educational growth on the part of all pupils. Be ready to point out that scientists and mathematicians are quick to indicate that they as individuals do not have all the answers. Even the top men in these fields admit they have a great deal to learn.

X. Alertness

The flowers being observed in the laboratory had five petals in 98% of the cases. One student, however, found a flower that had six petals and soon convinced all the other students that they should draw flowers with six petals. All with the exception of one alert pupil who quickly examined several other flowers before announcing that

there was evidence to show that not all of the flowers had six petals. In fact the majority of those in the laboratory had five petals. Alertness of observation and of mind is indeed important to men of science and mathematics. In another instance, pupils were drawing cross sections of a bean stem. Most of the class were using drawings which were already done for them in their textbook. One boy, however, announced that the book differed with his findings in the laboratory session the day before, for he had found that at one stage of development the bean stem was hollow; the book did not indicate this. Upon further examination, the teachers and the pupils found out that the boy was right; the stem was hollow during this one particular stage in its development. This is adequate to indicate that alertness plays an important role in the success of men in science and mathematics.

Suggested activities for fostering alertness:

1. Develop a keenness of mind which is ready to question material which apparently contradicts actual findings made in class and laboratory work.
2. Be careful about pointing out what pupils should expect to find as a result of some research or observation. In most cases they will find exactly what the teacher has said they should, unless an alertness and suspicion of preconceived ideas is developed.
3. Point out the many instances in science which involve the disproving of ideas which were thought true for hundreds of years.
4. Place an emphasis on the development of an alert mind through the placing of importance on proof, research, keen observation, and other things relative to such development.
5. Use teaching methods which provide opportunities for pupils to develop a sense of alertness such as experimentation techniques, observational activities and others of value.

SUMMARY

Certainly, all of the valuable traits, qualities, or characteristics for fostering future success of potential scientists and mathematicians in our high schools have not been exhausted in this article. Administrators, teachers, and others interested in education will be able to see other valuable characteristics and ways to develop them in the pupils in their schools. The personal traits listed in this article, however, seem important enough to be given special consideration by schools and communities who work with youth.

A college teachers' shortage will be the nation's most crucial educational problem by 1970, the President's Committee on Education Beyond the High School told the President.

BUILDING CONCEPTS OF TWO IN THE ARITHMETIC VOCABULARY

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Current research studies have pointed to the superiority of an arithmetic program built upon a sound and broad vocabulary, particularly at the primary level in the elementary school. Computational skills should follow the vocabulary approach.

Some teachers are prone to think that the vocabularly of arithmetic is a rather concise and technical one. This is not necessarily true. Each of the ordinal numbers carry many direct and indirect meanings, depending upon how they are used.

Through the assistance of a group of some thirty South Texas public school teachers, a rather extensive list of the meanings of the number, two, has been collected. This list was compiled through scanning children's literature, noting classroom experiences, and observing both the written and oral remarks of children. Surprising was the realization that the concept of two is found with such numerous contextual meanings. Some few concepts which could be understood only above the elementary school level are included in the compilation, but they are arranged in order of difficulty.

In the primary grades concepts of two will naturally begin with references to parts of the body. The human anatomy includes two arms, hands, legs, eyes, ears, feet, nostrils, thumbs, knees, and elbows. First and second grade youngsters will readily recognize the fact that they shed their milk teeth in pairs. Incidentally, the term, bicuspid, will be learned in the intermediate grades. False teeth are a set of uppers and lowers; eyeglasses are a pair. Adolescent boys will become proud of their developing biceps.

In the lower grades the family is the center of interest for learning situations. References to people can furnish meaningful concepts of two, such as; mother and father, husband and wife, parents, grandparents, brother and sister, twins, you and I, couple, mates, sweethearts, twosome, and vice-president.

Teaching units in the lower grades contain a wealth of arithmetical concepts of two. Accessories and articles of clothing come in pairs, i.e., shoes, sox, gloves, a pair of pants, earmuffs, twin sweaters. The terms, topcoat and underwear, denote two layers of clothing.

While studying about shelter the young child can become acquainted with the following concepts of two: two-story house, upstairs, second floor, duplex, sub-flooring, double windows, French doors, two-car garage, bunk beds, double bed, two-bedroom house, two-bath house.

Furthermore, a study of transportation could involve the following meanings of two: two-door sedan, two-car family, two wheel bike, bicycle, double-decker bus or train, round trip. The parts and accessories of an automobile are often found in pairs. There are two seats, headlamps, and footpedals. The wheels, doors, and windows of automobiles are arranged in pairs.

In the locality where this list was compiled, a number of the children are from families of military personnel. They hear every day references to the second in command, a second lieutenant, a two striper, and two bars.

According to the prescribed arithmetic curriculum in the primary grades, children are taught to handle money. They learn that two nickels are one dime; two half-dollars are one dollar. In learning the measurement of time they are exposed to the use of the seconds on a clock, the second hand, the hour of two o'clock, and every two hours. The terms, biannual, semiannual, bicentennial, bihourly, and fortnight might also become meaningful. Liquid measures taught in the primary grades include the facts that two pints are a quart and two half-gallons are a gallon. The upper grade curriculum continues with two cups in a pint, two ounces in one-fourth cup, and two tablespoons in one ounce.

The purely technical terms of mathematics include the numbers 2, 20 (two tens), 222, 2,222, each adding a different concept to the value of the Arabic numeral 2. Other concepts of two taught at the primary level include the Roman numeral II, second, and the fraction, $\frac{1}{2}$, presenting the reality of a whole cut into two parts; two pieces, two rows or columns, and two lines (stick men or tallies). The intermediate and secondary grades follow up with other fractions such as $\frac{2}{3}$, $\frac{2}{10}$, $\frac{2}{7}$, which are still different concepts. The decimal fractions .002, .02, and .2 present concepts of two through another facet of our number system. On the upper levels minus two, the power of two, and the term, square, come into use. The meaning of bilateral and bisect are also presented.

Geography and maps afford several concepts of two, namely; two hemispheres are paired (Eastern and Western or Northern and Southern). There are two continents in the Western Hemisphere. On city maps are found Second Streets; and there are words referring to the place where two streets or roads converge; crossing, junction and fork.

In addition to all these concepts of two there are those which are purely literary or linguistic. Initially, there are those words prefixed with *bi*. As a prefix, bi means twice, doubly, two, or having two. Bigamy, bipod, and bifocal are but a few of such words. There are a number of words beginning with *du*, duce, dual, duel, and duplicate,

for instance, which bear concepts of two. Likewise, words beginning with *di;* such as ditto, diphthong, dioxide, didymous and divergent, are indicative of a two concept. Moreover, words whose roots are two or whose compound parts contain two; twice, twixt, two-fold, twosome, two-ply, two-way, two-pence, two-penny, provide further enrichment. In addition to these there are also Siamese, pair, double, and set.

Still other expressions denoting two are "second chance," "two times," "do it again," second-hand, used, repeat, "two sides to a question," and "both sides of the paper." One may make a choice between two things or alternatives. There are comparisons such as "two of a kind," "tall and short," and "one large and one small."

What classroom is not besieged with colloquialisms and/or slang expressions now and then? "Double-cross," "two-fisted," "two-faced," "two-bits," "snake eyes," "second rate," "on the double," and "It takes two to tango" are all concepts of two.

When the group compiling our list of concepts of two summarized their findings, they discovered that these more than one-hundred and fifty ideas of the meaning of two are only the beginning. They are still discovering new terms everyday.

TINY X-RAY GENERATORS TO FIGHT MALIGNANCIES

Medical science has a new weapon to fight malignant growths—tiny X-ray generators that can be made into needles, capsules or sandwiches and implanted in the human body. The miniature X-ray machines promise to eliminate the bulky, complex and expensive X-ray apparatus now being used to bombard cancers.

The tiny generators, some can be made to measure one-tenth of an inch in diameter and three-tenths of an inch long, are the invention of Dr. Leonard Reiffel, supervisor of the nuclear radiation section of the Armour Research Foundation, Chicago, Ill.

ROBOT "BRAINS" FIGURE BEST ELECTRIC POWER SCHEDULES

Analog computers are now being used to see that electric power is dispatched to users such as factories or local power companies on the most economical schedules possible.

More of the computers are taking over as automatic "watchmen" of today's vast electrical generation-transmission networks, and are being put to work to figure the best and most economic routes for the electric power sent out to consumers. The electronic "brains" do this by setting up internal electrical-mathematical "models" of the power system, and rapidly solving problems fed into them by referring to these models.

Electrical analog circuits are the first to solve this economic dispatch problem exactly and directly, since the computers make possible changes in routing the electricity at minimum expense, and provide a great deal of additional information about the vital workings of the power network.

USING MAGNETS IN THE ELEMENTARY GRADES TO TEACH SCIENTIFIC UNDERSTANDINGS

Alphoretta Fish
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Elementary-school science is not difficult to teach. Yet, many teachers have an aversion to teaching it for, at times, it would seem that the curriculum of elementary-school science is in need of definition and direction. Teaching the subject at such times leaves a teacher with a feeling of inadequacy. For instance, how many teachers have asked themselves, "What scientific attitude is being developed by allowing children to 'experiment' with magnets and an assortment of objects?" They ask, "If children must study magnets in the elementary-grades, isn't there some way to plan activities that will develop some understanding of scientific attitude?" It was just such questions that stimulated this investigation.

While considering the objects to be used with the magnets, the discovery was made that a number of scientific understandings could be developed if the teacher planned to control the distribution of the objects to be used in the activity. Therefore, it was decided to use a wide variety of materials and, at the same time, "plan for disagreement" by giving

(1) a steel pin to one group of children, a brass pin to another group
(2) a plastic thimble to one group of children, a steel thimble to another group
(3) only those metal objects which the magnet will attract to one group of children, metals which cannot be attracted by the magnet, as well as those that can, to another group.

The plan follows:

Divide the class into committees. Instruct the committees that they are to work independently and are not to discuss their work or their findings with any other committee. Give each committee one or more magnets and a ***planned*** assortment of objects.

Instruct the students: Experiment with the magnets and the objects. Discuss your findings with the members of ***your*** committee, and try to come to some definite conclusions. Be prepared to report your conclusions to the class.

When the committees have concluded their experimenting and are ready for the discussion, prepare for the probable conflict of "conclusions" by stressing the fact that a meeting of scientists should be carried on in an orderly manner. Interruptions are not only discourteous but delay the purposes of the meeting; therefore, ***after*** the reading of each report, committee members who have comments or

questions will raise their hands and wait for recognition from the person making the report.

From the disagreement of ideas and opinions brought out during the discussion, the teacher should be prepared to help the children discover that:

(1) Scientists must withhold judgment until all aspects of the problem have been examined and tested.

(2) Such statements as, "A magnet will pick up pins" is a "finding" and cannot become a "conclusion" until it has been proven to be true. And, in this connection, the only conclusion that has been arrived at in this experiment, so far, is that a magnet seems to have an energy which enables it to attract *some* materials—but not all.

Also, during the discussion, guide the children's thinking along these lines: Why do we disagree? What is wrong? What do we need to find out? Suggest that the two committees that are in disagreement work together to discover for themselves that while their materials are alike in name, they are unlike in composition. Follow through by suggesting that all the committees "pool" all the objects that a magnet will attract. Analyze with the class the composition of these objects (use references); help them make their own conclusions; and have ready the references which will verify these conclusions.

Another aspect of this experience which should be stressed is the importance of "pooled" knowledge to scientific discovery and advancement. Moreover, by "pretending" that each committee represents a group of scientists from a different part of the world, it can be further demonstrated *how* scientists are able to gather information on a world-wide basis.

CONICS FOR THANKSGIVING

CLARENCE R. PERISHO
Mankato State College, Mankato, Minnesota

The thesis that conics are fun has been well developed by Norma Sleight.[1] Her examples have dealt with spring and Easter motifs.

In college analytical geometry courses starting in the fall, the normal season for such activity is Thanksgiving or Christmas. With the aid of an art student the following was prepared and given as an announced test on the last class before Thanksgiving vacation.

Plot the following all on *one* set of axes. Use a scale of about 5 units to one inch.

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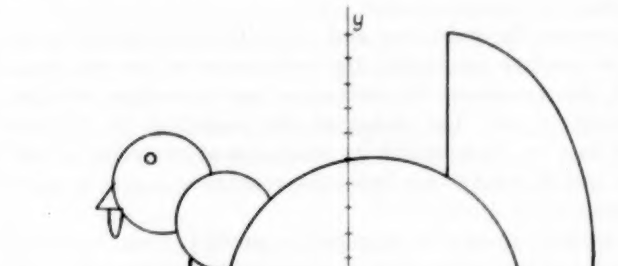
[1] Sleight, Norma, "Conics Are Fun," SCHOOL SCIENCE AND MATHEMATICS, 45, pp. 787–791, December, 1945.
———, "More Fun With Conics," SCHOOL SCIENCE AND MATHEMATICS, 47, pp. 303–304, April, 1947.
———, "Com(n)ics," SCHOOL SCIENCE AND MATHEMATICS, 50, pp. 525–526, October, 1950.

1. $(X-1)^2+(Y-2)^2=36$
2. $\dfrac{(X-4)^2}{36}+\dfrac{(Y-4)^2}{81}=1$ (Plot right half only.)
3. Connect points (4, 7) and (4, 13).
4. Connect points (4, −5) and (4, −3).
5. $\dfrac{(X-\frac{1}{2})^2}{(2.5)^2}+\dfrac{(Y+6)^2}{4}=1$ (Plot upper half only.)
6. $Y=-6$
7. Plot $(X+5)^2+(Y-5.5)^2=4$ (stopping where it intersects previously drawn figures).
8. Plot $(X+7.5)^2+(Y-7)^2=4$ (stopping as in No. 7).
9. Connect (−10.2, 6) with both (−9.5, 7) and (−9.2, 6).
10. $16(X+8)^2+16(Y-8)^2=1$
11. Plot $16(X+9.5)^2+\dfrac{(Y-6)^2}{1.44}=1$ (stopping as in No. 7).
12. Plot $(X+5.5)^2+\dfrac{(Y-3.5)^2}{4}=1$ (stopping as in No. 7).
13. Plot $\dfrac{(X+5.5)^2}{\frac{1}{4}}+\dfrac{(Y-1)^2}{4}=1$ (stopping as in No. 7).
14. Draw the quadrilateral with vertices at (−9.5, −0.5), (−8.3, −0.7), (−10.5, −2.7), and (−9, −3).
15. Connect (−8.6, −2) with (−2, −3.2).
16. Connect (−8.5, −1.5) with (−3, −2.5).
17. Draw $\dfrac{(X+9.5)^2}{(2.5)^2}+(Y+3)^2=1$ (stopping as in No. 7).
18. Connect (−7, −3) with (−6, −6).
19. Connect (−12, −3) with (−13, −6).
20. Say "YUM, YUM."



LOW COST 60 CYCLE RESONANCE DEMONSTRATION APPARATUS

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The phenomena of electrical resonance and the characteristics of tuned circuits in general may be easily and effectively demonstrated with apparatus assembled from a discarded radio speaker, an ordinary radio capacitor and a low wattage light bulb.

The apparatus consists of an inductance comprised of the field coil and its core from an electrodynamic radio speaker, a capacitor of from one to eight microfarads capacitance and a 6 watt light bulb connected in series across a 110 volt 60 cycle A.C. source.

A discarded speaker of the type described may be obtained by the asking from most any radio repairman or may be taken from a discarded radio. The field coil and core are removed with a hack saw. The correct size capacitor can be purchased from many radio repair shops, or may be ordered from any electronics supplier. The light bulb is available from any lamp dealer.

Not all field coils have the same reactance, so a little experimentation may be necessary to locate the capacitor which will produce resonance. Various values of capacitance within the range cited should be used along with varying the inductance by raising or lowering the core into and out of the coil. Resonance is, of course, indicated by maximum brightness of the lamp. Several values of capacitance may be desired in order to make changes in the circuit for student interpretation and calculation.

By varying the inductive and capacitive reactances as described above to produce resonance, the inductance of the coil may be calculated. At resonance, the inductive and capacitive reactances are numerically equal. The value of the capacitor in microfarads is marked thereon, from which its reactance at 60 cycles is readily calculated and equated to the inductive reactance to give a value for the inductance at 60 cycles.

The student should be required to predict, from information determined and preceding and accompanying explanations, the effect of a change of value of any of the circuit components on the phase angle, total current and voltage across each component. Graphical representation should accompany algebraic calculations of actual numerical values and angles.

It is hoped the apparatus described will be of help to the instructors who desire to acquaint their students with the fundamentals of alternating currents, but lack funds for the purchase of more expensive assembled demonstration apparatus.

JUST STAND OUT OF THE WAY!

PAUL WESTMEYER
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Of concern to some educators for a long time, and to most educators recently, has been the problem of what to do with the gifted students in our classrooms. There is no doubt that we have a great many gifted students. Also there is no doubt that they are in the minority in most classrooms. If special effort is made to teach for the benefit of this group we quickly lose the interest of the majority of the class. But, if we do not provide some challenge for these gifted students we quickly lose their interest. In large schools, where the number of such students is large, there often are special classes in several fields. But, in the smaller schools the difficult choice is between (a) teaching above the heads of the majority to encourage the better students, and (b) teaching on the level of the average student and so discouraging the gifted, or worse yet, encouraging them in a life of laziness.

As in most situations of this nature where a choice apparently must be made between dichotomous courses of action, there really is a third choice. Obviously if the teacher insists upon teaching the same thing to all members of a class (keeping the class together seems to be a major goal in traditional teaching) he does have only the two choices. The key then is *not* being concerned with keeping the class together.

In the elementary grades we very often find the class divided into "bears," "blackbirds," "beavers," etc. The pupils are taught in ability groups where everyone has a chance for some success among those of his own level. A few junior and senior high schools carry this same plan to the extreme of having "dumb," "average," and "smart" sections of each class. This is making distorted use of the good idea begun in the elementary grades. If we are going to do this we might as well set up a multiple track system of education. This is neither necessary nor desirable.

Perhaps this problem is most acute in the sciences for we are very concerned not only with encouraging our best students to continue in science studies but also with attempting to interest more students in this area. We have seen in recent years that our traditional methods of teaching have not been doing the job. School after school has dropped one or more science courses or has relegated them to alternate-year offerings when they should have been adding new courses to keep up with science in this modern changing world. Evidence shows that the interests of children are largely scientific.[1] Why then

[1] R. Will Burnett, *Teaching Science in the Elementary School.* Rinehart, N. Y. 1953. Pp. 8, 10, 11–14.

are secondary school science courses not more popular? Is it the stultifying effect of traditional teaching methods? Are only a few possessed of the ability to become scientists? Perhaps so, but this number is certainly greater than indicated by present trends. Furthermore, in a world so dependent on scientific technology shouldn't everyone be somewhat familiar with the very basis of his daily living?

No tremendous upheaval resulting in sweeping changes in the science curriculum is needed. Chemistry, physics, biology, and the other sciences taught in high schools do need to be brought up to date continually to include modern science. But, the real change needed is in method.

Students of greatly varied abilities and interests will be more likely to enroll in science courses if they know that they will have some chance to be successful and to pursue their own special interests. Such an opportunity can be provided by using small group methods instead of the usual whole-class lecture-discussion-demonstration methods. The small groups can be set up in a variety of ways for a variety of purposes—they should not always be set up on the basis of mental ability. But, in most cases each individual will have a better chance to "prove his worth" in such a small group than he will in a large group.

With such an arrangement the teacher can spend more of his efforts trying to interest more students in science and, once interest has been aroused, he can *let them learn* as they desire. (Comenius said we should strive for a situation in which students would learn more and teachers would teach less.) As for the gifted students who have become interested in science all the teacher has to do is *just stand out of the way*. As a matter of fact, that is what he will *have* to do in many cases. These "top notch" students may actually be hampered by attempts to teach them for (a) chances are not very great that their science teacher will be well-enough prepared in such a variety of subjects that he can even keep up with their efforts, and (b) if they are not encouraged to study on their own they will just that much more slowly, if at all, develop the self-directing abilities that they will need if they are to realize their potential.

In addition to general use of small group methods there are two curriculum offerings that plainly encourage self-directed study. One is the encouraging of special projects which are presented to the class in a sort of seminar manner within regular classes.[2] The other is the provision of a special "class" for the same purpose. I have administered such a class for the past two years and will describe it briefly. (Either of these plans, by the way, will work just as well in a small school as in a large one, if not better.)

[2] Jackie Mallis, "A Seminar for Superior Students." *The Clearing House*. 31, 175–178. Nov. 1956.

This second offering is not a class in the sense that a group of students meets with a teacher one hour a day five days a week. Rather students enroll in the program just as in any other class and it is scheduled at a regular time. Also it carries the same credit as any other regular course. In our case the class, which we call Advanced Problems in Science, is scheduled for the first hour of the school day during which time the teacher in charge of this class is actually teaching another group. The class is small since requirements for admission are based on scholastic achievement and previous experience in science courses. Specifically, the student must have taken the course basic to the area in which he wants to study in Advanced Problems. Further, he must have demonstrated superior ability both to learn in the field of science and to apply his efforts wisely when studying on his own.

A student who is thus eligible and interested must prepare an outline of his proposed study in Advanced Problems. When this is approved by the teacher in charge of the course, admission requirements have been met. During the year spent in this course, usually the senior year, the student must follow his approved plan of study, developing a broad knowledge of the field of science in general at the same time.

The students make daily reports to the teacher on a dittoed form telling where they worked and what they did (very briefly) and stating any problems encountered. On the same form they may request a conference with the teacher of the course or with any other member of the science department whenever they feel they need it. Notebooks are kept and these are checked by the teacher periodically. The whole group occasionally takes a field trip and usually meets together once a week to hear a report from one of the members and to discuss his study with him.

A small room is set aside as headquarters for the students in Advanced Problems in Science. They have the meetings there. Most of them keep some equipment there. Some study there most of the time. In addition all have a key to this room and other students are ordinarily not admitted.

Factual tests are seldom given in this class. Evaluation is made by the teacher and a student on the basis of how intensely he has applied his efforts to his problem and how much he has advanced in his general scientific knowledge. The first year of operation of the course the Co-operative Test on Natural Science was given to the members of the Advanced Problems class and to students in a biology class. The Advanced Problems students ranked at the 98th, 97th, 96th, and 95th percentiles. A statistical comparison of this group with a group from the biology class, matched only on the basis of grade point

average for six semesters of high school work, showed the mean raw score of the Advanced Problems group to be significantly above the mean raw score of the other group. Since there were no controls in any real sense and since the comparison was made on only one basis, these results can hardly be interpreted to mean that this special course does anything special for the students. However, it does tend to show that at least the course didn't hurt them.

We made a conscious and sincere effort to *stand out of the way* and let the students pursue their studies with a minimum of teacher direction and the results were apparently quite good.

"HOW WOULD YOU ANSWER THIS?"

EUGENE D. NICHOLS
Florida State University, Tallahassee, Fla.

On page 39 of the January, 1957 SCHOOL SCIENCE AND MATHEMATICS the following problem appeared:

> Because the symbol π always has a value of $3\frac{1}{7}$ it is called a (1) radius (2) circle (3) variable (4) circumference (5) constant

On page 296 of the April, 1957 SCHOOL SCIENCE AND MATHEMATICS the wording of the problem above was criticized as "a type of carelessness which may cause the student trouble in later work." The following rephrasing, which "could avoid the trouble" was suggested:

> Because the symbol π always has a fixed value (approximately $3\frac{1}{7}$) it is called a . . .

I want to claim that both wordings are ambiguous. To say that "the symbol π has a value" or "a fixed value" is rather humorous. No one should doubt the fact that a symbol is something one can see on a page, hence it is a printed mark. What, then, determines the value of this symbol? The amount of ink used? Or how difficult it is to print it?

Thus, it appears that the authors did not intend to say anything about the symbol 'π,'[1] rather they wanted to make a statement about the number π. About all that could be said is that the difference between the numbers π and $3\frac{1}{7}$ is a number with a small absolute value.

[1] I am following a convention commonly used by logicians to use single quotations when speaking of a symbol for a thing, rather than of the thing itself.

REPORT ANTI-MALARIA DRUG WORKS AGAINST ARTHRITIS

An anti-malaria drug called chloroquine has been found to be 70% effective against rheumatoid arthritis and works in a completely different way from cortisone and its derivatives.

WHY NOT USE CROSS-NUMBER PUZZLES AS A TEACHING AID WITH YOUR GENERAL MATHEMATICS CLASSES?[1]

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There is nothing new about cross-number puzzles. They were probably produced about the same time as crossword puzzles. The cross-number puzzles, however, though easier to construct, have had none of the popularity of the daily newspaper crossword puzzles. Though a number of the puzzles have been published in educational periodicals and a few writers have included a number of them in their texts, the uses of the puzzles have been pretty much limited to those of mathematical recreations. The possibility of using these puzzles as a teaching aid has seemingly been overlooked.

TYPES OF PUZZLES

The common cross-number puzzle, or cross-figure puzzle, as it is sometimes called, is very similar to the crossword puzzle. It differs in that digits are used to form numbers instead of using letters to form words. It is similar in that it includes a puzzle block, along with horizontal and vertical columns of items that are used to provide definitions or answers for filling in the block.

Another type of cross-number puzzle that is popular consists of a puzzle block that includes partially completed equations. From information that is provided by the completed portion, the remaining digits or symbols necessary to complete the puzzle can be determined.

Examples of these types of puzzles are provided with this article.

VALUE OF PUZZLES FOR CLASSROOM USE

Teachers who have used cross-number puzzles as a teaching aid have voiced praises concerning their usefulness.[2] They indicated that the puzzles were an excellent medium for arousing interest, for providing a class with constructive work that the majority of pupils could do while the teacher offered help to individual pupils, for remedial work whereby youngsters could discover their own errors, for

[1] This article includes excerpts from "A Collection of Cross-Number Puzzles," by Louis Grant Brandes (J. Weston Walch, Publisher, Box 1075, Portland, Maine, 1957. 226 pp.)

[2] A survey of selected teachers who had used cross-number puzzles with their classes, conducted during April, 1956, indicated the reactions of these teachers to the puzzles.

providing a "painless" review of a unit of work, and for "special" classroom lessons and/or homework assignments. However, there is little in the literature to confirm these praises.

Willerding has written about one very definite objective to be achieved through the use of cross-number puzzles.[3] The following remarks have been taken from one of her articles:

"It is very difficult to stimulate the interest of junior and senior high school students in review of the fundamental processes of arithmetic. If the review is given in traditional "deadly" drill, few of the objectives of the review are accomplished. Answers are written unenthusiastically and the same errors appear which the drill is attempting to correct. Number games which stimulate such review in the elementary grades are too childish for the "sophisticated" high school students.

"A good review of the fundamental processes is the cross-number puzzle. The cross-number puzzle differs from the crossword puzzle only in that it uses numbers instead of words. Not only is such a number puzzle a good review of fundamental processes, but it is an excellent motivating factor in the teaching of arithmetic."

Concerning an additional means of using the puzzles, Willerding adds:

"After one class had learned how to work the cross-number puzzle and had become enthusiastic about it, time was taken to explain the make-up of the puzzles. Showing them the simple designs, we discussed the techniques for their construction. Then the students tried creating an original puzzle using simple designs.

"Soon some of the brighter students were making puzzles of these, as well as much more complicated designs. They presented their puzzles to the class. The class was eager to try each original puzzle and to detect any error in the puzzles. New problems were created by the class to correct the errors in the original puzzles. Needless to say, a review of the fundamental processes of arithmetic was accomplished with enthusiasm and interest."

Brandes has also pointed out the possibilities of the cross-number puzzles for classroom use:[4]

"There are a great many types of mathematical puzzles that lend themselves to classroom use. Included among such puzzles are written puzzles, number puzzles, maze puzzles, cut-up puzzles, mathegrams, line puzzles, and cross-number puzzles. Perhaps the most useful of the puzzles, as a teaching device, is the cross-number puzzle.

"Before children can enjoy solving cross-number puzzles it is usually necessary to teach them the method of solving such puzzles. Once this has been accomplished, cross-number puzzles can be developed for classroom use for any particular unit of work in mathematics. Such puzzles provide individual challenge for pupils and serve as an excellent remedial device by which children can discover their own errors. The puzzles serve to provide a "painless" way to review mathematics materials that can be effective both as a classroom lesson and as a home or study period assignment. Cross-number puzzles can readily be developed on units of arithmetic, algebra, and geometry."

An article edited by Berger provides eight suggested steps for con-

[3] Willerding, Margaret F. "Review of the Fundamental Processes; The Cross-Number Puzzle," SCHOOL SCIENCE AND MATHEMATICS, January, 1954, pp. 51–52.

[4] Brandes, Louis Grant. "Recreational Mathematics as It May Be Used With Secondary School Pupils," SCHOOL SCIENCE AND MATHEMATICS, May, 1954, p. 390.

structing cross-number puzzles.[5] As to the use that can be made of the puzzles the article offers the following suggestions:

"The puzzles may be drawn and worked out on classroom blackboards or separate copies made for all students by duplication processes. After presenting the idea to the class it is well to devote a full period to giving directions, showing the students how to outline the squares, and acquainting them with the numbering system. Students should be permitted to work at their own rate in class, and be encouraged to make similar puzzles at home."

EXAMPLES OF CROSS-NUMBER PUZZLES

1		6		2	=	3
9		2		8	=	3
5		3		2	=	6
=		=		=		=
5		6		8	=	3

CROSS-NUMBER PUZZLE WITH SIGNS OF OPERATION

Directions: You are to insert the signs of operation (+, −, ×, and ÷) in the empty spaces that will provide the indicated results with the given numbers. A correct solution will "check out" horizontally and vertically.

EXAMPLES OF CROSS-NUMBER PUZZLES

Examples of cross-number puzzles to serve for review purposes for eighth-graders and above have been presented by Smith[6] and Brandes.[7] A puzzle on measures, useful for sixth- or seventh-grades, has been presented by Janicki.[8]

Willerding has presented a cross-number puzzle with Roman numerals.[9] This puzzle includes duplicate puzzle blocks. One of the blocks contains Roman numerals, the other block is blank for the

[5] Berger, E. J. (Editor) "Devices for a Mathematics Laboratory," *The Mathematics Teacher*, January, 1951, pp. 31–34.

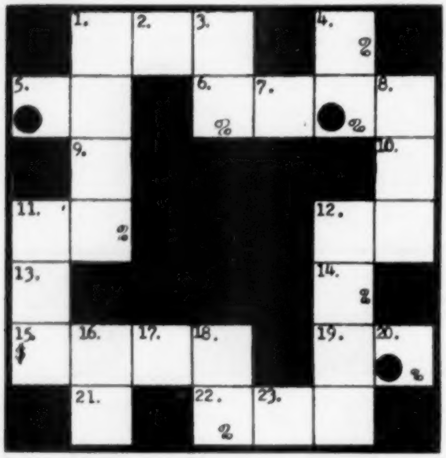
[6] Smith, J. R. "Cross Figure Puzzle," SCHOOL SCIENCE AND MATHEMATICS, June, 1945, pp. 476–478; "Cross Figure Puzzle," *Mathematics Teacher*, January, 1954, pp. 30–31.

[7] Brandes, L. G. *Op. cit.*, pp. 391–393.

[8] Janicki, G. "Cross Figure Puzzle," *Arithmetic Teacher*, February, 1956, p. 16.

[9] Willerding, M. F. "Roman Numbers Puzzle," *School Activities*, February, 1956, p. 183.

SHORT REVIEW OF PER CENT



Horizontal

1. How many hundredths are in 125%?
4. Express six hundredths as a per cent.
5. Express 36% as a decimal fraction.
6. Find 4% of $1,036.
9. Change 25% to number of 12ths.
10. $\frac{1}{2}$% of 400.
11. 26 is what per cent of 40?
12. 12 is 20% less than what number?
13. Take 62$\frac{1}{2}$% of 3$\frac{1}{5}$.
14. What per cent of 1.4 is .07?
15. 3% of what amount is $41.04?
19. 5.76 is 120% of what number?
21. 20% less than 5 is 50% of what number?
22. 180.6 is what per cent of 84?

Vertical

1. 500% of 327.
2. Change 200% to a whole number.
3. 2.7 is what per cent of 5?
4. Express $\frac{18}{25}$ as a per cent.
5. Find 2$\frac{1}{2}$% of 120.
7. .25% of 400.
8. 476 is 112% of what number?
11. 37$\frac{1}{2}$% of 1,656.
12. 515 is 33$\frac{1}{3}$% of what number?
16. 140% of what number is 53.2?
17. 7.2 is 20% more than what number?
18. Express .82 as a per cent.
20. 1.6 is what per cent of 20?
23. 50% more than 2 is 300% of what number?

purpose of writing in the Arabic numbers that correspond to the Roman numerals.

There are numerous examples of crossword puzzles prepared for classroom use with subjects other than mathematics. Most of these, however, have been prepared for use with social studies units in the middle elementary grades. Brown[10] and Clampett[11] have provided a number of puzzles for chemistry students that are similar to the cross-number puzzles. These puzzles make use of chemistry symbols instead of numbers or words. Answers to the horizontal and vertical

[10] Brown, C. L. "Crossword Puzzle in Chemistry Symbols," *Journal of Chemical Education*, June, 1954, pp. 298–299.

[11] Clampett, B. H. "Crossword Puzzle," *Journal of Chemical Education*, Sept., 1955, p. 449+; October, 1955, p. 519+; December, 1955, p. 632+.

items are chemistry symbols indicating formulas or elements that are to be filled in the puzzle block. These puzzles, like the cross-number puzzles, appear to have excellent teaching possibilities.

Nygaard has presented another type of puzzle, which resembles a crossword puzzle, that he refers to as the dictoform.[12] A puzzle block is provided, with indicated spaces for horizontal and vertical words. As a clue to each word, a definition or description is provided. When a word has been identified, it may be written into the proper space using various permutations of its letters, the order of which is determined as other words are identified. Though the puzzle presented in the article is concerned with definitions from both science and mathematics subject areas, words of a more specific nature could as readily be provided. It appears that the value of this puzzle is more for stimulating thinking than as a teaching aid that can be related to specific materials.

In an effort to provide a variety of puzzles for classroom use with seventh-, eighth-, and ninth-graders, Brandes has provided a collection of thirty cross-number puzzles.[13] This collection includes a sample for teaching the procedure for solving the puzzles, thirteen puzzles covering various units of arithmetic, and sixteen puzzles with digits and signs of operation. The units covered by the thirteen puzzles include whole numbers, fractions, decimals, per cents, squares and square roots, measures, and general review; the puzzles with digits and signs of operation are completion-type, designed to provide a more complete understanding of the four fundamental operations with whole numbers. The latter type of puzzles, suggested by examples produced by the Arithmetic Committee of the Oakland Public Schools,[14] has proved of special interest to seventh- and eighth-graders.

RELATED MATERIALS

Though the material in the literature is very limited concerning the use of cross-number puzzles, there is considerable information regarding the use of recreational mathematics materials. Much of the latter is applicable to the use of cross-number puzzles.

In commenting on the importance of motivation, Breslich states:

> "It is a well-known fact that superior results are obtained when the pupil is genuinely interested in the work to be done."[15]

He further comments:

[12] Nygaard, P. H. "Can You Solve a Dictoform?" SCHOOL SCIENCE AND MATHEMATICS, January, 1949, pp. 6–8.

[13] Brandes, L. G. "Math. Can be Fun," Portland, Maine: J. Weston Walch, Publisher, Box 1075, 1956, pp. 29–59.

[14] *Ibid.*, page 56.

[15] Breslich, E. R. "The Technique of Teaching Secondary-School Mathematics," Chicago: The University of Chicago Press, 1930, p. 62.

"Pupils, as well as adults, find much pleasure in attempting to solve the mysteries of mathematical puzzles, falacies, and illusions. Such material, properly related to classwork, can therefore be made a valuable aid to teaching."[16]

Bakst, a leading writer in the field of mathematics, has written:

"It is not what we teach that is important. The important thing is the way we teach. The same topic may be presented in a purely abstract form, and it will fall flat. Dress up this topic in something which has a human touch in it, and it becomes a huge success."[17]

Parker has presented the "pros and cons" concerning the use of recreational materials in the classroom and has provided a sampling of available materials and the methods for using these materials in teaching mathematics.[18] In using the term "puzzles" to include various types of recreational mathematics materials, she has stated:

"In the voluminous amount of literature which has been produced concerning the use of puzzles in the classroom, there has been attributed to puzzles every conceivable objective, from thought-provoking recreations to a means of improving attitudes, except as a method of teaching mathematics."[19]

"It is my contention that puzzles can be made to serve dual purposes:

1. To secure the interest and attention of the group.
2. To teach mathematics by illustrating and clarifying certain mathematical concepts and techniques by securing a higher mastery of subject matter, by developing skill in manipulation, by making mathematics learning more permanent, and by developing an appreciation of the systematic approach of algebraic methods."[20]

Martha Pierce has stated her opinion that the solving of puzzles is of interest to everyone. She has written:

"There are certain instincts innate in every one of us, the instinct of curiosity and the instinct of self, or the ego-instinct, which gives us the increasing desire to solve puzzles. We love to be confronted by a mystery and we are not entirely happy until we have solved it, even though the only reward to our work may be the pleasure derived from the knowledge that we ourselves have reached the solution. The spirit of rivalry stimulates every person to solve the puzzles which come to him and keep on a level with his companions.

"The solution of puzzles brings other rewards as well. It stimulates the imagination and develops the reasoning power. We often learn little tricks that are great time-savers in our later work."[21]

After illustrating how each of a number of recreations can be effectively used in teaching mathematics, Parker summarizes her views effectively. She has written:

"It appears that we may safely conclude that most of us have a 'puzzle instinct' and that the puzzle question at the right time and place will not only make a class more interesting, but can further the primary responsibility of the teacher, i.e., teaching mathematics. . . .

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[16] *Ibid.*, page 79.

[17] Bakst, Aaron. "Recreational Mathematics," *The Mathematics Teacher*, April, 1950, p. 290.

[18] Parker, Jean. "Using Puzzles in Teaching Mathematics," *The Mathematics Teacher*, April, 1955, pp. 218–227.

[19] *Ibid.*, p. 218.

[20] *Ibid.*, p. 219.

[21] Pierce, Martha. "Mathematical Recreations," *The Mathematics Teacher*, Jan., 1926, p. 13.

"Puzzle material properly related to classwork can, therefore, be made a valuable aid to teaching."[22]

In a recent article, Hall writes:

"The outcome of strategic use of recreations not only includes a better attainment of the aims of mathematics relating to attitudes and appreciations, but also a greater achievement of the other objectives. This is no doubt due, in part, to recreations promoting a wholesome learning situation and also providing a powerful means of instruction."[23]

He adds:

"It is difficult to make a sharp distinction between recreational and non-recreational materials."[24]

Two similar studies, carried out to determine the effect of using recreational mathematics with pupils in mathematics classes, have been reported.[25] In each case, where recreational mathematics was presented to an experimental group and withheld from a control group, marked differences in achievement, as measured by standardized tests, were in favor of the experimental group.

Hall used mathematical recreations as one of the means for reducing the emotional outlook of college freshmen whose thinking was blocked with regard to mathematics.[26] His results indicated that the recreations, when accompanied by the effort to relate mathematics to the students' goals, might offer a valuable approach to resolving the unfavorable outlook by students upon the mathematics subjects.

Observations

The following observations are supported by this review:

1. Although cross-number puzzles seem to have definite usefulness as a teaching aid, as has been indicated by teachers who have used them with their classes as a teaching device and by their potential use as a mathematical recreation, it appears from the amount of space devoted to them in the literature that their possibilities have been greatly overlooked.

2. A number of examples, as well as a number of different types, of cross-number puzzles are provided in the literature. There are sufficient number to provide teachers who wish to make use of them with a variety of puzzles for their classes.

3. The findings of studies reported and the analysis of other con-

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[22] Parker, *op. cit.*, p. 225.

[23] Hall, A. J. "Using Mathematical Recreations in Junior High School," *The Mathematics Teacher*, November, 1955, p. 484–487.

[24] *Ibid.*, p. 485.

[25] Porter, R. E. "The Effect of Recreations in the Teaching of Mathematics," *School Review*, June, 1938, pp. 423–427.

Brandes, L. G. "Math. Can Be Fun; Tricks, Puzzles, Wrinkles Raise Grades," *The Clearing House*, October, 1950, pp. 75–79.

[26] Hall, A. J. "A Study of Non-Achievers in Mathematics." Unpublished master's thesis, Stanford University, 1941.

tributors to the literature concerning the use of recreations with mathematics classes lends strong support for the use of cross-number puzzles as a teaching aid.

4. Although related studies support the use of mathematical recreations in the classroom, there is no indication of a study having been conducted to support the use of cross-number puzzles as a teaching aid. Such a study could well serve to improve teaching of the mathematics subjects in our secondary schools.

If you have not used cross-number puzzles as a teaching aid for your classes, by all means plan to do so. The puzzles will delight the children and you will be pleased with the results.

MAGNETISM HELPS AMPLIFY WEAK MICROWAVES

A new device for amplifying extremely high frequency radio waves called microwaves depends on the material ferrite, used to make the tiny cores for the magnetic memories of some electronic computers, Bell Telephone Laboratories reported. The wavelengths of microwaves start at about 15 inches and become smaller with higher frequencies. Ordinary radio waves can be as long as 15 miles.

The tiny experimental amplifier is mechanically simple, consisting of a magnet and coaxial cables that "pump" microwaves into and out of a tiny resonant cavity containing two very small disks of ferrite, a magnetic compound of iron and oxygen used for memory storage units in some electronic computers.

The new amplifier, developed by Drs. H. Suhl and M. T. Weiss of the Laboratories, amplifies radio waves by changing extremely high frequency microwaves into more powerful waves of slightly lower frequency.

This property is expected to be a tremendous help in fields dealing with weak signals such as radio astronomy, radar and microwave "relaying" that transmits many telephone conversations and television over radio beams.

ENROLLMENTS INCREASE

Young America is showing an increased interest in mathematics and science for the first time in almost half a century, the Office of Education reported today.

Results of a recent study on enrollments in science and mathematics, to be published in full by the Office of Education in a few months, show that last fall there was a small increase in the percentage of public high school students enrolled in mathematics and science courses.

The increase in the percentage of students enrolled in such courses, although slight, was the first since 1910. Until last fall, the percentages had been generally on the decline.

Despite the previous percentage declines, the total number of students enrolled in these courses has increased steadily and is now the highest in the Nation's history.

The Office of Education pointed out that signs of increasing interest in science and mathematics among high school students have special significance at a time when rapidly expanding technology, rising standards of living and increasingly complex military needs create a demand for more scientific manpower.

The Office said that the increase in the proportion of pupils taking courses in science and mathematics was probably due in part to the fact that more and more schools have been offering such courses. Some schools, on the other hand, have introduced such subjects as a direct result of student interest.

A REPORT ON THE ARGONNE NATIONAL LABORATORY COURSE FOR HIGH SCHOOL SCIENCE TEACHERS

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I am not a high school science teacher now, but did teach for several years at that level. However, my interests, professional and personal, are with teachers of science from the kindergarten through the university. Hence, when the opportunity presented itself for taking a course in a "Survey of Nuclear Energy" at the Argonne National Laboratory at Lemont, Illinois, from June 10 through June 26, 1957, it was eagerly accepted.

The Argonne National Laboratory is located at Lemont, Illinois, which is about 24 miles west of the University of Chicago, 18 miles north of Joliet, and one and one-half miles southwest of the intersection of routes 66 and 83. The laboratory was founded in 1946 and is an installation of the Atomic Energy Commission administered by the University of Chicago.

The course was initiated, planned, and taught by members of the Argonne National Laboratory staff who are members of the local branch of the Research Society of America. The reason for their giving this course is that they were aware of the tremendous need for science by the public, and what better way to help the people become familiar with recent advances in nuclear energy than by presenting their teachers with the opportunity of getting practically first hand information not only from scientists working in this field, but also from the actual materials and apparatus used. The scientists realized that many of the developments in the field of the atom are so recent that many of the high school science teachers of today did not have an opportunity to study about them in college. They also realize that the young teachers who did study about these advances may not have had the opportunity of doing any laboratory work, or of observing any of the accelerators, reactors, mass spectroscopes, or other apparatus used in nuclear research, or even if there were a small number of teachers who were so fortunate as to have had these experiences, they still could benefit from the latest apparatus and hearing the bevy of specialists in all phases of nuclear science who were conducting research at Argonne National Laboratory.

The University of Chicago was kind enough to provide graduate credit to any students who desired it. The fee for the course was but ten dollars. In charge of the course and co-ordinator was Dr. Leonard

Katzin. There was room for 25 students, but only 21 enrolled. There were thirteen meetings from 8:45 until 5 with time for lunch and no classes on Saturday or Sunday. No facilities were provided for the students to sleep on the grounds of the Laboratory, but the cafeterias were available for lunch.

Most of the students enrolled in this course lived within a radius of forty miles. The ones coming the greatest distance were from St. Paul and Minneapolis, Minnesota. The ages of the participants ranged from that of a college senior to one within one year of compulsory retirement. It was a most congenial group of dedicated people. They had received no stipend as in the National Science Foundation Institutes, yet had been willing to give of their time and money so that they could improve themselves and thereby better help their students.

The atmosphere was informal. The members of the Argonne staff who took part in this course did their utmost to help us in our understanding of what they had been and were doing and the progress that man has made in pushing back the darkness surrounding the structure of the atom. They realized that our budgets for obtaining equipment are grossly inadequate and so they devised and are looking for ways of demonstrating important principles of nuclear science with inexpensive equipment. Indeed, they presented us with radioactive materials and instructed us in their uses and the necessary safety precautions.

We were the first class. Another class was taught in July. Next summer the course will be given again, the number of times depending on the demand. We who took the course have been letting other teachers know about it and will spread the good word, for it is really worthwhile.

Lectures

The first lecture was concerned with the history, purposes, administration, and description of the Argonne National Laboratory. It was for the purpose of orientation. On the average there were two lectures daily for the remainder of the course. Some of the lectures lasted 45 minutes, others twice as long. None were given by amateurs. As a matter of fact, the top people at Argonne in their respective scientific fields made up the course faculty.

The topics covered in the lectures included the structure of the atom, energetics, fission, fusion, the half-life, radiation effects, accelerators, reactors, tracers, radiological chemistry, radiological physics, metallurgy related to nuclear fuels, energy levels of the nucleus, chemistry related to nuclear science, radiobiology and genetics, and medical and industrial uses of radioactive isotopes.

Laboratory Work

Prior to taking this course the mass spectrometer was something we had read about. When one reads about a complex instrument, there cannot be much appreciation or understanding. However, in the laboratory under the direction of Dr. Henry Stanton we constructed one with his help. What a great significance this instrument has now taken on. No longer is it something that we have to visualize from the pictures in a textbook.

We made diffusion cloud chambers, and they worked. To say we used Geiger-Mueller counters and other radiation detecting instruments is an understatement. We determined half-lives of some radioactive isotopes. We studied the inverse-square law.

We were introduced to radioautography. Plants grown from irradiated seed were placed on film. Plants grown from seeds unirradiated and irradiated at various doses were compared as to visible growth characteristics. A tomato plant was treated with phosphorus-32 and the uptake of the radio-phosphorus was observed by monitoring the various parts of the plant at different intervals.

One of the top metallurgists in the world, Dr. Bernhard Blumenthal took all 21 of us into his metallurgical laboratory and with his illustrious assistant directed and aided us in making fuel elements, the actual type used in the reactors. When we completed this work we were allowed to take part of the fuel element for our schools. Of course, the materials that we got are not our personal property, but the property of the schools where we teach. Try to order one of these fuel elements from any scientific supply house in the United States, or abroad. In the metallurgy laboratory we performed experiments on the expansion of uranium and steel due to heat. We also had the opportunity of lifting a regular fuel element which consists of enriched uranium. We hardly got it off the table. Have you ever lifted a gold brick? Gold has a specific gravity of 19.32 and uranium 18.68, so they are quite similar in density.

Rats which had been irradiated were dissected for us so that we could see the effects on the different organs. The rats had been exposed to different doses.

The response of a population to irradiation was studied by exposing equal amounts of a solution of yeast cells to a powerful ultra-violet light for different lengths of time. Controls were also used. A small amount (the same in each case) of each control and each irradiated solution was transferred to potato dextrose agar in Petri dishes and after 48 hours the visible colonies were counted and a curve plotted of per cent survivors against time.

Other laboratory work included preparation of a metallographic

specimen, coprecipitation, resin adsorption, and solvent extraction.

Installations Visited

We were shown the cyclotron, the van de Graaff, and the Cockroft-Walton accelerators. The plans for the proposed 12.5 billion electron volt accelerator were shown to us and the opportunity to ask questions was afforded. This project has an estimated cost of $27,000,000 and will greatly aid in increasing man's knowledge of the structure of the atom. It will take about four years to build this atom smasher whose technical name is the proton synchrotron.

Much has been in the newspapers recently about irradiated food. The High Level Gamma Irradiation Facility proved to be a most interesting sight. The materials which are to be irradiated, such as canned food, are sealed in waterproof, thin-walled aluminum urns which are lowered through 20 feet of water and then transferred by means of a long-handled instrument into the radiation rack. The source of the gamma radiation consists of spent reactor fuel elements. The water acts as a shield. A very interesting effect is when the light above the water is turned off, the water has a blue glow due to the radiation.

Tours were taken to the laboratories of the chemistry, physics, and biology divisions of the Argonne National Laboratory. Treatment of halide crystals with high frequency X-rays with the resulting change in color of the crystals was shown along with the effect of low temperature and light on the resulting colors.

Plants living in an atmosphere of carbon dioxide whose carbon was the radioactive isotope C^{14} were observed. One of the most fascinating trips was to a room in the biological laboratories which consisted of concentric tiers of shelves surrounding a central trapdoor in the floor. At 1 A.M. the trapdoor opens and a platform on which is Co^{60}, or radioactive cobalt, rises above the level of the floor. For a designated time, the animals are exposed to this radioactive source and then it returns to the depths beneath the floor. The exposed animals are studied and their offspring and succeeding generations intensively investigated for radiation effects, especially on heredity.

We were shown the mass spectrographs in operations at the Laboratory. In addition, we saw the new mass spectrograph which is being constructed. It will be one of the three largest in the world, all being in stages of construction at present. The man responsible for its design told us all about this piece of apparatus, answered our questions, and then went to lunch with us.

The various reactors at the installation were visited. As the Argonne Research Reactor was undergoing repairs we were fortunate to see its internal anatomy. It uses enriched uranium for fuel and

heavy water serves as the coolant and moderator. The Argonaut was visited next. This reactor is for University training. It is water-cooled, smaller than other reactors, and especially designed for instruction and research in reactor physics. It is the cheapest reactor available for colleges and including the building to house it the cost is estimated at $100,000.

The EBWR, or experimental boiling water reactor, was the subject of another tour. The Argonne National Laboratory constructed the first reactor of this type and on July 17, 1955, it generated enough electricity to power and light Arco, Idaho. Steam which is produced as a result of nuclear energy in the reactor is used to drive turbines to generate electricity. This type of reactor is serving as the prototype of many nuclear power plants.

Literature Distributed to Class

The Biological Effects of Atomic Radiation, a Report to the Public, National Academy of Sciences-National Research Council, 1956
The Biological Effects of Atomic Radiation, Summary Reports, National Academy of Sciences-National Research Council, 1956
Crossroads for Nuclear Research, 1956
Should You Be an Atomic Scientist?
Argonne National Laboratory Annual Report, 1956
The Technology of Power Reactors
Electric Power from the Atom
You Can Understand the Atom
The Nuclear Research Reactor Design, Construction, Operation
Uses of Isotopes in Medical Research, Diagnosis, and Therapy
Uses of Isotopes in Industry and in Physical and Chemical Research
Uses of Isotopes in Agricultural Studies
Lists of Films on Atomic Energy Which Are Available
The Argonne High Level Gamma Radiation Facility
Uses of Radioactive Isotopes
Argonaut—Argonne's Reactor for University Training, by R. H. Armstrong and C. N. Kelber
Atomic Shooting Gallery, by A. W. Martinez
How to Construct a Small, Electric Tube Furnace, by R. F. Vogt
The Argonne Research Reactor

Equipment

Equipment which the course participants received included a specimen of radioactive Strontium, or Sr^{90}, with a lead shield, materials for assembling a cloud chamber, an electroscope which we built, a mass spectroscope which we built, a uranium rod and a steel rod to show thermal cycling and isotropy, a piece of uranium embedded in lucite so that the uranium will not be oxidized by the air, irradiated sunflower seeds, radioautographs, and a few samples of uranium ores.

Concluding Remarks

One thing which impressed all members of the class was the accuracy and small quantities with which the scientists at Argonne Na-

tional Laboratory were able to work. A vacuum equivalent to a pressure of 10^{-14} mm. of mercury could be attained when needed. Quantities of radioactive isotopes with a mass of 10^{-12} grams were utilized in analyses and reactions.

It is not possible to mention all of the individuals from the Argonne staff who contributed to the success of the course. Among them were Dr. Leonard Katzin, Dr. Young, Dr. Bernhard Blumenthal, Dr. Earl Phelan, Dr. Peter Klein, Dr. Henry Stanton, Dr. E. P. Steinberg, Dr. Sheffield Gordon, Dr. Asher Finkel, Dr. Stanley Shapiro, Dr. George Thiel, and Dr. George Svihla. These individuals and others on the Argonne Staff have certainly done their part in trying to improve the teaching of science in our schools. All of the course participants were very favorably impressed with the experiences in this course and the result will be reflected in their teaching which can't help but be improved because of this grand opportunity which we had. Our advice to any teachers reading this article is to enroll in the Argonne National Laboratory course for High School Science Teachers next summer, if you have an opportunity.

NEWEST ELEMENT CHRISTENED NOBELIUM

The world's newest element, atomic number 102, has been christened nobelium, with No as its chemical symbol.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS

During the last few years the Board of Directors of the CASMT has given careful consideration to the problems involved in electing the officers of the Association. Recently the President appointed a committee to study our election procedure and submit a proposal for the revision of the present method. The report of this committee follows.

PROPOSED PLANS FOR NOMINATION AND ELECTION OF OFFICERS

1. A Nominating Committee shall be appointed by the Executive Committee of the Board of Directors promptly following the annual meeting. Publication of the personnel of this committee shall be in an early issue of SCHOOL SCIENCE AND MATHEMATICS. At this time the membership shall be invited to make suggestions of prospective candidates to any member of the Nominating Committee.
2. The Nominating Committee shall consist of five (5) members, with the Chairman being chosen from the group by the Executive Committee. The personnel of the committee shall be so selected as to present a balanced representation of the Association according to sectional, geographical, and level-of-teaching areas of distribution.
3. It shall be the duty of the Nominating Committee to name two candidates

each for the office of President and Vice-President, and twice as many candidates as there are positions to be filled on the Board of Directors. All nominees must be members of the Association currently in good standing and properly qualified. It shall be the responsibility of the Board of Directors, at the time of its Spring meeting, to determine whether all persons whose names appear on the list of nominees meet these conditions.

4. It shall be the duty of the Chairman of the Nominating Committee to secure from each nominee a professional biography, and from the nominees for President and Vice-President a glossy print of a recent photograph. This shall be done in time to provide copy for mailing to the membership of the Association at least five weeks prior to the date set for the annual meeting.

5. The Board of Directors shall designate at the Spring meeting the exact date for the official election which shall be held during the four weeks closing at 12 midnight of the date one week prior to the annual meeting. Ballots will be mailed to the members of the Association in good standing so that they may be returned during the official election period.

6. The votes shall be counted under the joint supervision of the Secretary of the Association and the Chairman of the Nominating Committee. In the event either of these persons cannot act the President shall appoint an alternate. The count shall be made in time to provide the President of the Association with the official results so that they may be presented to the Board of Directors at its first official session of the Annual meeting. In the event of close votes the Board of Directors may exercise the privilege of calling for a recount, and, in the event of a tie vote, it shall assume the responsibility of determining the procedure for selection of the candidate to be declared elected.

7. It shall be the duty of the President to announce the names of those elected. This shall be done at the time of the annual business meeting and published in an early issue of SCHOOL SCIENCE AND MATHEMATICS. No public announcement shall be made of the number of votes received by any candidate.

8. Make appropriate changes in the constitution for the inauguration of the suggested plan.

Respectfully submitted:
H. GLENN AYRE
MILTON O. PELLA
F. LYNWOOD WREN, *Chairman*

As a result of the preceding report, the Board of Directors approved the following Constitutional changes at their annual meeting in May, 1957. As required by the Constitution, these proposed changes must be printed in the *Journal* in the two issues published prior to the annual meeting in November. Hence, they are presented below and will appear again in the November issue. These changes will then be voted on by the membership of CASMT at the Annual Meeting in Chicago in November.

CONSTITUTIONAL CHANGES NECESSARY TO INAUGURATE PROPOSED PLAN FOR NOMINATION AND ELECTION OF OFFICERS

In the left column appears the new wording of the affected part of each article of the constitution. In the right column appears the present wording of the same portion. The new words are italicized.

ARTICLE III—SECTION III. ELECTION, TENURE OF OFFICE, AND COMPENSATION

(a) The President and Vice-President shall be elected by *a majority of the votes cast by members of the Association* and shall serve for a term of one year or until their successors are elected. The Treasurer and Business Manager . . . shall be fixed by the Board of Directors.	The President and Vice-President shall be elected by the members of the Association at the annual meeting and shall serve . . . shall be fixed by the Board of Directors.
(b) *The election of officers of the Association shall be by mail ballot to be held each year during the four weeks closing at 12 midnight of the date one week prior to the annual meeting. Official ballots, accompanied by professional biographies of all nominees and pictures of the nominees for President and Vice-President shall be mailed to the members at least five weeks prior to the date set for the annual meeting. Ballots, when properly marked, shall be returned to the Secretary of the Association to be held under seal until the time for the official count. In the event of close votes the Board of Directors may exercise the privilege of calling for a recount, and, in the event of a tie vote, it shall assume the responsibility of determining the procedure for selection of the candidate to be declared elected.*	(b) No (b) section.

ARTICLE IV, SECTION IV. ELECTION, TENURE OF OFFICE, AND CONVENTION

Directors shall be elected by a *plurality of the votes cast by members of the Association. Those candidates declared elected to membership on the Board of Directors shall be the required number of nominees receiving the largest number of votes cast in the annual election as described in Section III, (b) of Article III.* They shall assume the duties . . . *where* the certificate *of* organization is recorded.	Directors shall be elected by a majority vote of the members present at any annual meeting. They shall assume the duties . . . when the certificate or organization is recorded.

ARTICLE V, SECTION II. NOMINATING COMMITTEE

(a) *Promptly following the Annual meeting of the association, the Executive Committee shall appoint a committee of five (5) to be known as the NOMINATING COMMITTEE; (b) The membership of this Committee shall be so selected as to present a balanced representation of the Association according to sectional, geographical, and level-of-teaching areas distribution; (c) The Chairman of the Committee shall be designated from this group by the Executive Committee; (d) The term of service on the Committee shall be one year; (e) The Committee shall nominate two candidates for the office of President and two candidates for the office of Vice-President, and twice as many candidates as there are positions to be filled on the Board of Directors; (f) All nominees must be properly qualified members of the Association currently in good standing; (g) The Chairman shall provide for mailing to the membership necessary pictures and professional biographies of the nominees; (h) The Chairman of the Committee and the Secretary of the Association shall have the joint responsibility of making the official count of all votes cast in the annual election. They shall provide the President of the Association prior to the time of the annual meeting of the Board of Directors, with a report, over their signatures of the results of the official count.*	The Nominating Committee shall consist of five (5) members chosen by the Executive Committee.

Delete:

ARTICLE II. SECTION VII. PROXIES: All members entitled to vote may cast their votes in person or through a duly accredited proxy.

Change numbering:
ARTICLE II. SECTION VIII. NOTICE OF MEETINGS
Shoule be changed to read:
ARTICLE II. SECTION VII. NOTICE OF MEETINGS

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

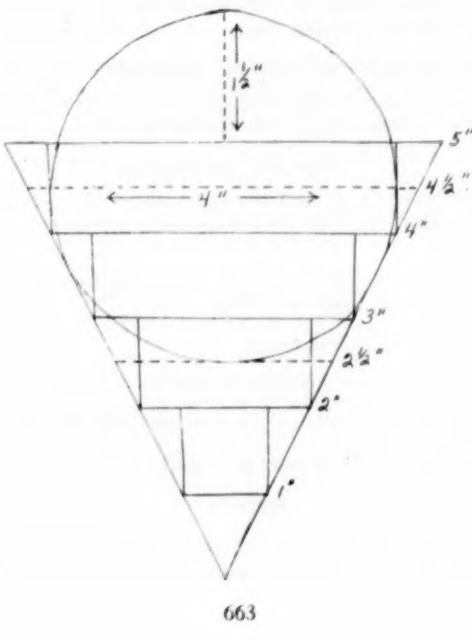
2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

2569. *Proposed by J. W. Lindsey, Amarillo, Texas.*

If an iron sphere 4 inches in diameter is placed in a conic vessel which is full of water and whose altitude and diameter are each 5 inches, how much water will run over?



Solution by J. E. Christian, Oxford High School, Oxford, Massachusetts

Two and one-half inches of sphere's diameter is submerged. The volume of the submerged spherical segment equals amount of water that will run over (Archimede's Principle).

$$V=\tfrac{1}{3}\pi h^2(3r-h)$$

("C. R. C. Standard Mathematical Tables," Pg. 340, Mensuration Formulae, Chemical Rubber Publishing Co., Celeveland 1956.)

$$V=\tfrac{1}{3}(3.141)(2.5)^2(3[2]-2.5)$$

$$V=22.903125=22.90 \text{ cubic inches}$$

Thus, nearly 23 cubic inches of water will run over.

Solutions were also submitted by Andy E. Forsberg, Westmont College; Sister Margaret Ann, Long Beach, Calif.; Augusto Rodriguez, Medellin, Colombia, S. A.; Warren Rufus Smith, Lake Leelanau, Mich.; and the proposer.

2570. *Proposed by Mary E. Estes, Bangor, Maine.*

Any straight time cutting a circle and passing through a fixed point, is cut harmonically by the circle, the point and the polar of the point.

Solution by Leon Bankoff, Los Angeles, California.

Let the secant PA cut the circumference of circle (O) in A, B ($PB<PA$), and let C, Q denote the intersections of the polar of P with PA, PO, respectively.

Then A, O, Q, B are concyclic, since $PQ\cdot PO=PB\cdot PA$.

Hence $\measuredangle AQO=\measuredangle ABO=\measuredangle OAB$ (since triangle AOB is isosceles).

But $\measuredangle OAB=\measuredangle PQB$, since each is the supplement of $\measuredangle OQB$.

It follows that $\measuredangle AQO=\measuredangle PQB$, and QC, QP are the internal and external bisectors of $\measuredangle AQB$.

Hence C, P divides A, B harmonically.

Solutions were also offered by Charles B. Tripp, Bridgeport, Conn.; and Walter R. Warne, St. Petersburg, Fla.

2571. *Proposed by A. R. Haynes, Tacoma, Washington.*

If the normals of the points P, Q, R of a parabola meet in a point, show that the circle PQR will go through the vertex of the parabola.

Solution by the Proposer

Let the points be common with the parabola $y^2-4ax=0$ and the equation of the circle through P, Q, R be $x^2+y^2+2gx+2fy+c=0$.

Then

$$\frac{y^4}{16a^2}+y^2+2g\frac{y^2}{4a}+2fy+c=0.$$

Now the coefficient of y^3 is 0, hence

$$y_1+y_2+y_3+y_4=0.$$

Let y_1, y_2, y_3 be the ordinates of P, Q, R respectively, then y_4 is the ordinate of the fourth common point.

But if the normals of P, Q, R meet at a point,

$$y_1+y_2+y_3=0$$

Hence,

$$y_4=0$$

But $y_4=0$ is the vertex of the parabola.

Hence the fourth point common to the parbola and the circle is the vertex.

2572. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Point out the fallacy in the following:

Since

$$2i \sin 3\pi = e^{i3\pi}$$

and $\sin 3\pi$ is 0.

Therefore

$$e^{i3\pi} = e^{-i3\pi};$$

that is

$$e^{6i\pi} = 1.$$

Therefore

$$6\pi = 0$$

Solution by the Proposer

$$e^{6i\pi} = e^0$$

merely asserts

$$6i\pi = 0 + n(2\pi i)$$

not that

$$6i\pi = 0$$

2573. *Proposed by Emily Smith, Romulus, N. Y.*

If A, B, C, are in arithmetic progression, show that

$$\sin A - \sin B = 2 \sin (A - B) \cos B.$$

Solution by Brother Felix John, Philadelphia, Pa.

There is an error in the statement of Problem 2573. I have tried several sets of numbers in Arithmetic Progression in the problem and they do not check.

First, I assumed that A, B, and C were the angles of any triangle. For example, I let $A=30°$, $B=60°$, and $C=90°$, with the following result:

$$\sin 30° - \sin 60° \text{ should} = 2 \sin (-30°) \cos 60°$$

that is,

$$\tfrac{1}{2} - \tfrac{1}{2}\sqrt{3} \text{ should} = 2(-\tfrac{1}{2})(\tfrac{1}{2}),$$

which is obviously incorrect. Then I let $A=45°$, $B=60°$, and $C=75°$. This yielded

$$\tfrac{1}{2}\sqrt{2} - \tfrac{1}{2}\sqrt{3} = 2(\tfrac{1}{4})(\sqrt{2}-\sqrt{6})(\tfrac{1}{2}),$$

not true again.

Secondly, I assumed that A, B, and C were any three numbers in Arithmetic Progression, like $A=30°$, $B=45°$, and $C=60°$. This gave

$$\tfrac{1}{2} - \tfrac{1}{2}\sqrt{2} = \sqrt{2}(\tfrac{1}{4})(\sqrt{2}-\sqrt{6}),$$

$$= \tfrac{1}{2} - \tfrac{1}{2}\sqrt{3},$$

almost, but not quite true.

Solutions were also offered by Lydia Brown, East Romulus, N. Y.; Millard F. Ernsberger, Culpeper, Va.; Sarah Hicks, Auburn, N. Y.; Daniel Kinne, Phila-

delphia, Pa.; Eva Snook, Yorktown, Va.; Jennie Warne, Philadelphia, Pa.; Walter R. Warne, St. Petersburg, Fla.; and Herbert Wolf, Chicago, Ill.

2574. *Proposed by Cecil B. Read, University of Wichita, Wichita, Kansas.*

Find maximum and minimum values of

$$\frac{x^2-2x+2}{2x-2}$$

without the use of the calculus.

Solution by the Proposer

Let the given fraction equal z, then

$$x=z+1\pm\sqrt{z^2-1}.$$

If $z=1$, $x=2$ and if z is less than 1, x is imaginary, hence a minimum value 1 when $x=2$.

Likewise if $z=-1$ at $x=0$, a maximum.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

The Student Honor Roll for this issue appears below.

2569. *Jack Gougoutas, Mansfield, Ohio.*

2569. *Nathaniel Queen, Brooklyn, N. Y.*

PROBLEMS FOR SOLUTION

2593. *Proposed by Cecil B. Read, Wichita, Kan.*

At the beginning of the Christian era, one dollar was invested at five per cent, compounded annually. Compare the present value of this investment with that of a solid ball of gold, the size of the earth.

2594. *Proposed by Brother Felix John, Philadelphia, Pa.*

Show that if $a(b-c)x+b(c-a)xy+c(a-b)y^2$ is a perfect square, the quantities a, b, c, are in harmonical progression.

2595. *Proposed by L. M. Ridder, Exeter, N. H.*

a) Find a three digit number which when multiplied by 2 reverses its digits. (Hint: there are no such numbers in the decimal system.)

b) Find a general formula for the digits and number base of a many-digit number which when multiplied by k will reverse its digits.

2596. *Proposed by Frank Peaslee, Cooperstown, N. Y.*

A rancher bought steers for $25 the head, and cows for $26 each. How many of each could he purchase for $1,000?

2597. *Proposed by John Satterly, Toronto, Canada.*

Show that in a plane triangle ABC whose sides a, b, c, are in the ratio 2.8/1.7/2.5, the line NIU joining N, the center of the nine-point circle, I the incenter, and U the Feuerback point, is parallel to the median drawn from C. (Reference may be made to Fig. 1, pp. 520, October 1956 issue of SCHOOL SCIENCE AND MATHEMATICS.)

2598. *Proposed by Earl Haines, Baton Rouge, La.*

Given the base and the vertical angle of a triangle, find the locus of the center of its nine-point circle.

EDITOR'S NOTE: THE PROBLEM SECTION OF SCHOOL SCIENCE AND MATHEMATICS IS IN NEED OF SOME NEW AND INTERESTING PROBLEMS.

BOOKS AND PAMPHLETS RECEIVED

A Key to the Stars, by R. Van der Riet Woolley. Third Edition. Cloth. 144 pages. 12×18.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

Acoustics, by Joseph L. Hunter, *Professor of Physics, John Carroll University.* Cloth. Pages xv+407. 15×23 cm. 1957. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $8.50.

Algebra, Its Big Ideas and Basic Skills, Book I, by Daymond J. Aiken, *Director of Curriculum and Former Head of the Mathematics Department, Lockport Township High School, Lockport, Illinois;* Kenneth B. Henderson, *Consultant in Mathematics Education, Illinois Curriculum Program, and Professor of Mathematics Education, University of Illinois;* and Robert E. Pingry, *Supervisor of Student Teaching in Mathematics and Associate Professor of Mathematics and Education, University of Illinois.* Cloth. Pages xiv+434. 15×23 cm. 1957. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y.

Algebra, Its Big Ideas and Basic Skills, Book II, by Daymond J. Aiken, *Director of Curriculum and Former Head of the Mathematics Department, Lockport Township High School, Lockport, Illinois;* Kenneth B. Henderson, *Consultant in Mathematics Education, Illinois Curriculum Program, and Professor of Mathematics Education, University of Illinois;* and Robert E. Pingry, *Supervisor of Student Teaching in Mathematics and Associate Professor of Mathematics and Education, University of Illinois.* Cloth. Pages xiv+434. 15×23 cm. 1957. McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, N. Y.

Algebra, Second Course, by John R. Mayor, *Professor of Mathematics and Education, University of Wisconsin, and Head of Mathematics Department, Wisconsin High School;* and Marie E. Wilcox, *Head of Mathematics Department, Thomas Carr Howe High School, Indianapolis, Indiana.* Cloth. Pages vi+458. 14.5×23 cm. 1957. Prentice-Hall, Inc., Englewood Cliffs, N. J. Price $3.32.

Arithmetic, Algebra, Logarithms and Slide Rule, with Practical Applications, by Robert L. Erickson, 2724 Waunona Way, Madison, Wisconsin. 80 pages. 15×22.5 cm. 1957.

Basic Mathematics for Radio and Electronics, by F. M. Colebrook and J. W. Head. 359 pages. 12×18.5 cm. 1957. Philosophical Library, Inc., 15 West 40th Street, New York 16, N. Y. Price $6.00.

Biology and Its Relation to Mankind, by A. M. Winchester, Ph.D., *Professor and Chairman of the Biology Department, Stetson University, De Land, Florida.* Second Edition. Cloth. Pages x+902. 15×23 cm. 1957. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, N. J. Price $7.25.

Chemistry—A Basic Science, by John C. Hogg, *Chairman, Science Department, The Phillips Exeter Academy, Exeter, New Hampshire;* Otis E. Alley, *Professor of Science, State Teachers College, Bridgewater, Massachusetts;* and Charles L. Bickel, *Instructor in Science, The Phillips Exeter Academy, Exeter, New*

Hampshire. Cloth. Pages xi+801. 15×23 cm. 1957. D. Van Nostrand Co., Inc., Princeton, N. J. Price $4.68.

College Physics, by Robert T. Beyer, *Associate Professor of Physics, Brown University*, and A. O. Williams, Jr., *Professor of Physics, Brown University*. Cloth. Pages xi+660. 15×23 cm. 1957. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $7.50.

Educators Guide to Free Slidefilms, Ninth Annual Edition, 1957, Compiled and Edited by Mary Foley Horkheimer and John W. Diffor, M. A., *Visual Education Director, Randolph, Wisconsin High School*. Pages vi+204. 21×27.5 cm. 1957. Educators Progress Service, Randolph, Wisconsin. Price $5.00.

Energy, by Sir Oliver Lodge. Paper. 64 pages. 14×22 cm. 1957. John F. Rider, Publisher, Inc., 116 West 14th Street, New York 11, N. Y. Price $1.25.

Fundamental Mathematics, by Leslie H. Miller, *The Ohio State University*. Paper. 323 pages. 21×28 cm. 1957. Henry Holt and Co., 383 Madison Avenue, New York 17, N. Y. Price $3.50.

Health and Fitness, by Florence L. Meredith, B.Sc., M.D., *Late Professor of Hygiene and Public Health, Tufts College;* Leslie W. Irwin, Ph.D., *Professor of Health Education, School of Education, Boston University;* and Wesley M. Staton, Ed.D., *Associate Professor of Health Education, Wayne State University*. Third Edition. Cloth. Pages x+450. 15.5×23.5 cm. 1957. D. C. Heath and Company, Inc., 285 Columbus Avenue, Boston 16, Mass. Price $4.20.

Illustrated Biology, Part Two: Animals, by Maud Jepson. Paper. 60 pages. 22×30 cm. 1957. John Murray, 50 Albemarle Street, London W. 1.

Insights into Modern Mathematics, Twenty-Third Yearbook of the National Council of Teachers of Mathematics. Cloth. Pages viii+440. 15×23 cm. 1957. The National Council of Teachers of Mathematics, 1201 16th Street, Washington 6, D. C.

Introduction to Electrical Applied Physics, by N. F. Astbury, *Professor of Physics, University of Khartoum*. Cloth. Pages xi+241. 14×22 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $10.00.

Introductory College Mathematics, by Robert W. Wagner, *Professor of Mathematics, University of Massachusetts*. Cloth. Pages xiv+430. 15×23 cm. 1957. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $5.50.

Journal of a Scientician, by Piero Modigliani, *Executive Director of Research for Modiglass Fibers, Inc.* Cloth. 136 pages. 13.5×21 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

Mammals of the Great Lakes Region, by William Henry Burt, *Professor of Zoology and Curator of Mammals at the University of Michigan*. Cloth. Pages xv+246. 13.5×21.5 cm. 1957. The University of Michigan Press, Ann Arbor, Mich. Price $4.75.

Modern Applied Photography, by G. A. Jones. Cloth. Pages vi+162. 12×18.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

Practical Physics, by R. W. Parsons, *Professor of Physics, University of Hong Kong*. Paper. Pages x+88. 16×23.5 cm. 1957. Oxford University Press, 114 5th Avenue, New York 11, N. Y. Price $2.00.

Prehistoric Man, by André Leroi-Gourhan, *Director, Museum of Natural*

History, Paris. Cloth. Pages ix+119. 14×21 cm. 1957. Philosophical Library, Inc., 15 West 40th Street, New York 16, N. Y. Price $4.75.

SCIENCE TEACHING IN SECONDARY SCHOOLS, by John S. Richardson, *College of Education, The Ohio State University.* Cloth. Pages xiii+385. 15×23 cm. 1957. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $6.50.

SET THEORY, by Felix Hausdorff, translated from the German by John R. Aumann, et al. Cloth. 352 pages. 15×23 cm., 1957. Chelsea Publishing Co., 552 West 181st Street, New York 33, N. Y. Price $6.00.

TEACHERS OF CHILDREN WHO ARE MENTALLY RETARDED, Prepared by Romaine P. Mackie, *Chief, Exceptional Children and Youth, Office of Education;* Harold M. Williams, *Psychologist, State Department of Public Instruction, Madison, Wisconsin;* Lloyd M. Dunn, *Coordinator for Special Education, George Peabody College for Teachers, Nashville, Tennessee.* Paper. Pages xii+97. 15×23 cm. 1957. U. S. Department of Health, Education and Welfare, Washington, D. C. Price $.45.

THE BOOK OF POPULAR SCIENCE. Cloth, 10 volumes. Vol. 1, 1–420 pages; 2, 421–848 pp.; 3, 849–1272 pp.; 4, 1273–1694 pp; 5, 1695–2120 pp.; 6, 2121–2538 pp.; 7,2539–2966 pp.; 8, 2967–3386 pp.; 9, 3387–3818 pp.; 10, 3819–4294 pp. (index vol.). 16×24 cm. 1957. The Grolier Society, 2 West 45th Street, New York, N. Y.

THE ELECTRICAL PRODUCTION OF MUSIC, by Alan Douglas, M.I.R.E. Cloth. 223 pages. 13.5×21.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $12.00.

THE HISTORY OF MATHEMATICS, by Joseph Ehrenfried Hofmann, *Honorary Professor, University of Tübingen.* Cloth. Pages xi+132. 13×20 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $4.75.

THE PRINCIPLES OF HEREDITY, by Laurence H. Snyder, Sc.D., *Dean of the Graduate College, The University of Oklahoma,* and Paul R. David, Ph.D., *Professor of Zoology, The University of Oklahoma.* Fifth Edition. Cloth. Pages xi+507. 16×23.5 cm. 1957. D. C. Heath and Company, Inc., 285 Columbus Avenue, Boston 16, Mass. Price $6.25.

VANGUARD! by Martin Caidin. Cloth. 288 pages. 13.5×20.5 cm. 1957. E. P. Dutton and Co., 300 4th Avenue, New York 10, N. Y. Price $3.95.

VISUAL METHODS IN EDUCATION, by W. L. Sumner, *Reader in Education; The University, Nottingham.* Second Edition. Cloth. 231 pages. 13×19.5 cm. 1957. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $6.00.

BOOK REVIEWS

SPECTROSCOPY AT RADIO AND MICROWAVE FREQUENCIES, by D. J. E. Ingram, M. A. (Oxon), D. Phil. (Oxon), *Lecturer and Research Fellow, University of Southampton.* Cloth. Pages xii+332. 13×21.5 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $15.00.

A broad field of research has developed since the last war, in which radio and microwave frequencies are utilized to extend spectroscopic research far into a new region. This has been largely possible because of the instrumentation and techniques that were developed in the communication laboratories for radar and microwave frequencies.

This excellent book by Professor Ingram gives a broad outline of the extensive work which has resulted from the above developments. The author has devoted space to sufficient theory and details of the experimental equipment to enable

the reader to gain an understanding of the methods used, as well as the importance of the type of information gotten from this type of experiment.

After the introduction and brief review of the development of the field, a number of topics are treated in some detail. Considerable space is devoted to the production, detection, and propagation of microwaves, and to the specific applications in microwave spectroscopy. The applications to gaseous microwave spectroscopy are well covered. Attention is also given to the measurement of paramagnetic resonance absorption of ions in the solid state, and to the investigation of ferro-magnetic resonance absorption. The application of radio-frequency spectroscopy to nuclear resonance, and nuclear induction experiments is treated as well as the application of the above work in nuclear physics, chemistry and solid state physics.

The book is well written. The chapter references are numerous and should be of special aid to those desiring to do additional reading. The book will be of particular interest to students of spectroscopy as well as physicists doing research in related fields.

M. B. SAMPSON
Physics Department
Indiana University
Bloomington, Indiana

A SHORT TABLE OF INTEGRALS, Fourth Edition, by B. O. Pierce, *Late Hollis Professor of Mathematics and Natural Philosophy at Harvard University;* Revised by Ronald M. Foster, *Professor of Mathematics at Polytechnic Institute of Brooklyn.* Cloth. Pages vii+189. 13.5×20.5 cm. 1956. Ginn and Company, Statler Building, Boston 17, Massachusetts. Price $2.25.

This is the fourth revision of Pierce's tables. The author claims the following changes in this revision: Previous additions have been inserted in their proper places, addition of a number of definite integrals, revision of section on Bessel functions, addition of a table of natural values of the gamma function, addition of certain information concerning other transcendental functions and some changes in the tables of exponential hyperbolic functions, squares, cubes, roots, and reciprocals.

The quality of paper in the reviewer's copy does not appear to be as good as that in many sets of tables. The printing is clear and easily read, although printed on an off-white paper. More of the long formulas are printed lengthwise on the page and hence there is less chance of error when using the tables. A table of contents in the front of the book replaced the page index which appeared at the end in the third revision.

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PLANE TRIGONOMETRY, Second Edition, by E. Richard Heineman, *Professor of Mathematics at Texas Technological College.* Cloth. Pages xii+167. 15×23 cm. 1956. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $3.75.

This text is a revision of an earlier one in which the lists of problems contain most of the changes. Additional problems are given and are arranged such that four different sets of problems are listed to cover the material presented in any one section. Answers to three-fourths of the problems are given and no answers are given for the fourth set.

It is surprising to note that the interpolation process requires that the small angle be at the top in all given examples rather than generalizing the process for any position of angles or numbers given. Only minor use is made of the idea of the unit circle in the discussion of variation of the functions. On page 56 the

students are asked to memorize the author's statement when a statement in the student's own words will have much more meaning to him.

In general the discussion material is good but some cases, such as the above, can usually be found in any text and this one appears to have less than the usual number.

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THE HISTORY OF MATHEMATICS, by Joseph Ehrenfried Hofmann, ***Honorary Professor, University of Tübingen.*** Cloth. Pages xi+132. 13×20 cm. 1957. Philosophical Library, Inc., 15 E. 40th St., New York 16, N. Y. Price $4.75.

As the preface suggests, this is a treatise; the style tends to be ponderous and in places the listing of many names with a line or less devoted to the contributions of the individual tends to be almost boring. Definitely the book would not be recommended as supplementary reading for secondary school students; it would well find a place as a reference work in any university library. The work prior to the Greeks as well as that of the Greeks is treated rather concisely. A check of somewhat obscure names revealed only two or three not mentioned which are not found in any single text or reference known to the reviewer. Again, however, one finds many cases where a name is mentioned with such little discussion of the contribution that one wonders if the mere listing of the name was worth the effort. An interesting and unusual misprint was noted on page 113.

From the viewpoint of a reference work adding to the stock of information available about the history of mathematics up to roughly the early 17th century, this is a definite contribution.

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ARITHMETIC, ITS STRUCTURE AND CONCEPTS, by Francis J. Mueller, ***Chairman, Department of Mathematics, Maryland State Teachers College, Towson, Maryland.*** Cloth. Pages xv+279. 15×23 cm. 1956. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.50.

As the author points out in the preface, this is not a text in methods of teaching arithmetic at various grade levels; it is rather a presentation of the subject matter of arithmetic at a mature level; with this out of the way, the texts in methods may then be utilized. The book seems a distinct contribution to the field.

There is probably more material than will be used in any single course, but the development is such that selection can be made without destroying continuity. The first chapter deals with our number system, treated primarily from the point of view of its historical development. Following chapters deal with synthesis (addition and multiplication), analysis (subtraction and division), comparison, fractions, and approximate numbers.

Certain aspects of the book pleased the reviewer: the historical approach seems a valuable one, at the same time there is not neglect of the meanings of the various procedures. The author takes care to present arguments both for and against the metric system, and is correct in his statement: "Unfortunately much of the pressure for adoption of the metric system in this country has had all the earmarks of an organized propaganda campaign which, typically, has left the celebrated 'man in the street' apathetic about the whole thing." In several cases there is an algebraic explanation of the process under discussion, of value to the reader with the necessary background, yet which can be omitted if desired. Some other points were less pleasing: on page 22 of the statement that "any number, whose exponent is zero, equals one" needs the qualification "any number, other than zero, whose . . . " On page 31, in discussing a number system with base five it is pointed out that there will be need for five basic symbols. "These will be 0, 1, 2, 3, and 4 . . . " They *may be* these, they *could* also be 0, \$, ω, π, and $+$.

In presenting tests for divisibility, tests are given for divisibility by 2, 3, 4, 5, 6, 8, 9, and 10. One wonders why 7 was not even mentioned. It was somewhat of a surprise to find the two and four dot notation (especially the four dots) in a proportion—will this never disappear? It is hard to see how even *in a sense* "times" and "is multiplied by" are inverse expressions (p. 169). The rule given for addition of decimals (p. 199) which suggests annexing zeros to the right if needed to complete the columns appears almost contradictory to the treatment of computation with approximate numbers in the next chapter.

The reviewer agrees that the expression $.\frac{1}{2}$ has no meaning; he is less willing to agree that "$\frac{1}{2}$ tenth" should be expressed as $.0\frac{1}{2}$. What on earth is wrong with .05? Some of these points are perhaps of minor importance. They are not sufficient to warrant rejection of the book as a possible text, without at least further study by anyone interested. It is doubtful if any great number of "lone readers bent on self-improvement," such as are mentioned in the preface, will be attracted.

CECIL B. READ

COLLEGE GEOMETRY, by Leslie H. Miller, *Associate Professor of Mathematics, The Ohio State University.* Cloth. Pages x+201. 15×23.5 cm. 1957. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $4.50.

This text contains a treatment of advanced Euclidean geometry by synthetic methods; it will probably find its greatest use in classes including prospective teachers, or perhaps summer courses in which secondary school mathematics teachers are enrolled.

The first chapter is almost entirely review of elementary plane geometry, but with emphasis on the reasons for handling the material as it is usually done. In fact, the treatment in the first four chapters is largely review, but additional material is included to extend the scope—for example, directed line segments, angles, and arcs; cyclic quadrilaterals; ideal lines and points; theorems of Ceva and Menelaus; more complex locus problems. The fifth chapter deals with elementary transformations, such as reflection, translation, rotation, expansion. The sixth chapter deals with inversion, including, among other topics, the question of invariance, and the problem of Apollonius. Chapter seven deals with projective properties, and treats the "double-ratio"; harmonic elements; complete quadrangles and quadrilaterals; duality; poles and polars; Desargues' theorem. Chapter eight is devoted to special points and circles associated with a triangle. The last three chapters include some material which the author suggests might be used as a basis for special reports rather than as parts of a basic course—the problem of Steiner; some special problems in quadrilateral construction; concurrent lines associated with a triangle.

Opinions as to the suitability of a text obviously vary; the number of texts in this field is relatively small, and this certainly merits consideration. The reviewer personally liked the approach of the first few chapters, with review and "deeper" consideration of elementary geometrical material.

CECIL B. READ

DRUG TREATMENT PRESERVES WESTERN WHITE PINE

Damage from blister rust, a fungus disease that annually destroys enough sawtimber to build more than 62,000 five-room houses, can be cut by treating affected trees with an antibiotic drug.

Acti-dione successfully halted the spreading fungus in a four-year trial of the drug on a stand of western white pine. A single application of Acti-dione killed between 77% and 80% of the cankers treated. Treatment consisted in pruning infected branches and partially cutting away trunk cankers in order to expose the disease-causing fungus. The drug, mixed with oil, was then applied to the cut surface.

IMPROVED CONDUIT "PIPES" MICROWAVE RADIO SIGNALS

"Piping" short radio waves around corners and sharp angles is expected to be made easier by a new lightweight "traveling-wave" conduit tube announced by the Radio Corporation of America.

One property of the very short radio waves called microwaves, measured in inches or less, is that they can be "piped" for short distances through tubes and conduits somewhat like water. One disadvantage of present high-sensitivity microwave conduit systems is the need for 30-pound electromagnets to focus the waves precisely down the axis of the conducting tubes. The alignment of the magnets is affected by vibration and changes in temperature, and must be adjusted periodically.

The new tube dispenses with the huge magnet, using instead a compact electrostatic focusing element built into the tube, and permanently aligned.

FORD PREDICTS DEVICE TO CLEAN CAR EXHAUST GASES

Promise of a device to "purify" automotive exhaust gases by passing them through a purifier located near a car's engine is forecast.

Such a device now looks possible through the discovery of a plentiful and inexpensive oxidation catalyst found by Ford Motor Company engineers during their anti-smog research. The catalyst, vanadium pentoxide, a yellow powder, successfully removed more than 80% of the offensive hydrocarbons in exhaust fumes during the equivalent of 4,000 miles of driving.


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